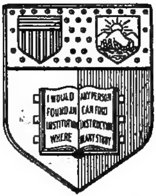
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THE LITERATURE OF AMERICAN ECONOMIC ENTOMOLOGY.

BY

E. P. FELT.

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THE LITERATURE OF AMERICAN ECONOMIC ENTOMOLOGY.

By E. P. Felt, *Albany, N. Y.*

Publication is undoubtedly our most important function, and while discussions of methods and lines of research may modify the matter made public, it seems to the speaker that a consideration of the form and method of publication may not be without value. This subject, it is true, has been mentioned more or less by my predecessors, and was discussed somewhat in detail by Dr. Forbes in 1893 and by his successor, Dr. Howard, in 1894. The address of the former constitutes one of the most critical analyses of a portion of our literature and of methods of publication, while that of the latter is an exceedingly complete record of what had then been published in economic entomology in this country and abroad. Dr. Forbes had occasion in 1893 to call attention to the fact that the literature of American economic entomology was increasing with great rapidity, and this has been even more manifest in later years. Somewhat over 10,000 newspaper articles about injurious insects have been published since 1860, while a rough estimate of the number of octavo pages devoted to the subject gives us a total of nearly 50,000, of which about one-quarter are found in bulletins of the agricultural experiment stations, and were therefore published since 1888. It is impossible to discuss this literature in detail within the time at our disposal, and only a few of its more salient characteristics can be brought out. It seems to the speaker that this is not the place for destructive criticism, and the following is presented in hopes that it may suggest methods whereby we may render our work of greater value to the general public. It is also well known to the speaker that his hearers are undoubtedly obliged to modify their publications, more or less, on account of conditions over which they have comparatively little or no control.

Dr. Forbes, as a result of carefully examining over 115 articles in 1893, came to the conclusion that economic entomologists were advancing more as a body of irregulars than an organized soldiery, and he drew from these publications the inference that we as a body were fairly well satisfied with our present methods of investigations; or, if not, at least were not in a condition to improve them at the time. He also failed to find a record in those publications of any new method of research, either adopted or proposed, in either field or laboratory; nor did he observe any noticeable departure from the stereotyped form of presentation, and he concludes that our methods of report and publication of dissemination and enforcement were lagging far behind our methods of research, and were receiving far too little attention. He also calls attention to the fact that we are very likely to forget that we are writing for the men to whom entomology is a perplexing, obscure, and displeasing subject, of which they know little or nothing good, while on the other hand they are frequently experts in crop inspection, and far quicker, as a rule, to observe injuries to their crops than are we, and much more likely to discriminate between them. He argues from this that crop injury and its characteristic appearance should lead in our discussions of injurious species, closely followed by remedial and preventive measures, and that a description of the insect and an account of its life history should be awarded a subordinate place, especially in monographic accounts, and calls attention to the comparative inefficiency of miscellaneous collections of articles, such as comprise the bulk of most reports and bulletins, so far as reaching the public is concerned.

The economic entomologist of America can not be charged with lack of energy and thoroughness, particularly when a species inflicts enormous losses upon staple crops.

A brief résumé of the literature reveals the somewhat surprising fact that over 1,825 octavo pages have been occupied by various writers in discussing the Rocky Mountain locust. The next insect to approach in importance this very serious pest, so far as the extent of the literature devoted to it is concerned, is the comparatively recently established San Jose scale, accounts of which already fill 1,160 pages. This species is closely followed by the excellent reports and the exhaustive monograph on the gypsy moth, comprising a total of 1,154 pages. The chinch bug comes next in importance, if we may judge of its rank by the 1,032 pages devoted to a discussion of it by various writers; and this is closely followed by the cotton worm with 908 pages, which is frequently treated of with its associate the bollworm, so that the two have monopolized 1,328 octavo pages. The codling moth is one of our older insects, and it is perhaps not surprising that 887 pages have been devoted to a discussion of its habits and the methods of controlling it, while the Hessian fly, also an early importation, has an extensive literature of over 629 pages. The periodical cicada has a literature extending over 647 pages, while 100 bulletins or separates, comprising 1,624 pages, are largely devoted to discussions of insecticides and apparatus for their application.

The estimates given above are only approximate, and have been rigidly limited to articles appearing in the more permanent bulletins and reports, no account being taken of newspaper articles. The entire literature of any one of these insects must be much more extensive than indicated by the above figures. It is probably impossible to avoid the somewhat extensive duplication of work represented by these figures, because the entomologist of each State is obliged to meet the demands of his constituents, and it is therefore frequently necessary to republish many well-known facts.

The monographic accounts of these species serve a very useful purpose in showing how much there is to be learned concerning each insect, and afford worthy models to inspire the investigator engaged in studying the life histories and habits of less known forms.

NEWSPAPER AND MINOR ARTICLES.

An estimate based on the bibliographies of American economic entomology and a calculation of the number of articles published between January 1, 1900, and December, 1902, gives the enormous number of 12,163 articles issued since 1860. This estimate includes not only newspaper articles, but also most, if not all, of the reports and bulletins published by American entomologists, and at the same time it probably omits a number of articles worthy of enumeration in this list. Undoubtedly some of the articles are practically duplications of others, and yet, after making all due allowance, we can hardly admit that less than 10,000 minor articles have been prepared for the public press by American entomologists during the last forty-two years. This is an enormous number, and despite the fact that some consider newspaper entomology as of little importance, the speaker can not help feeling that this mass of literature represents a very important part of the work of the economic entomologist. Reports are issued for the public, bulletins are prepared for the general dissemination of information, but the man who wishes to learn concerning an insect pest is much more apt to read his agricultural or local paper than to go to his bookshelves and search for some report or bulletin which may contain the desired facts. In other words, the speaker is inclined to believe that our newspaper and minor articles are much more generally read than the more detailed notices given in reports and bulletins, and on this account he considers newspaper entomology a very important factor in developing our work, and believes that all articles prepared for the press should receive careful attention and be adapted to the readers of the periodical. The attention of scientific men is not infrequently called to ridiculous statements concerning scientific facts in daily or weekly papers. Such are not calculated to inspire respect for the publication, and yet do they not indicate an opportunity of which we may avail ourselves? They show that the publishers recognize the demand for scientific information. The paper attempts to meet it in much the same way as it supplies information concerning many more familiar things. The reporter, who is of value in working up the account of a railway wreck, may fail when he discusses the life history of an insect; and we, as economic entomologists, should undertake, so far as possible, to supply this demand with concise popular accounts, giving the facts which the people wish to know. We can never entirely suppress sensationalism, but we can exert a strong influence toward moderation, and the speaker is of the opinion that most agricultural journals of America have already come under its influence, and as a rule apply to reputable parties for information, rather than rely upon unknown sources. The work begun with the agricultural and horticultural press can be gradually extended till most of the reputable weekly and daily publications of our country recognize the necessity of securing accurate information regarding various phenomena in natural history, and insist upon placing such before the public. This desirable end, however, will be brought about gradually, and will be hastened in proportion as we appreciate the importance of the subject and give these popular articles the necessary attention. We can not expect the public to appreciate the desirability of accurate information on this subject if those who pose as authorities are content to give out inaccurate, undigested, poorly worded articles in answer to queries. The agricultural and daily press of America is worthy the best we can give it, and in proportion as we meet that demand will we be successful in extending the influence of the work in which we are interested.

REPORTS.

Aside from newspaper articles, this form of publication has been the first employed in ecomomic entomology. The earliest report is that by Dr. Thaddeus William Harris, of Massachusetts, whose classic writings form the basis of all subsequent work in this branch of natural history. There is no necessity for the speaker describing or praising this work, since his hearers are all familiar with it, and it suffices to call attention to the fact that Dr. Harris's work is really a practical systematic account of the more important species known at that time.

The admirable series of reports prepared by Dr. Asa Fitch, entomologist of the New York State Agricultural Society, and practically State entomologist of New York, are equally well known and contain a mass of information with which every worker in this branch must familiarize himself if he would succeed. The arrangement of the reports by Dr. Fitch is very different from that obtaining in Dr. Harris's treatise and consists in a systematic grouping of the insects under important food plants. Dr. Fitch evidently believed in making his writings accessible to those who were not entomologists and who had no special interest in the subject. His reports form the beginning of a series which in reality was continued by Dr. Lintner, though in different form, the latter's reports being composed very largely of detailed accounts of species which had come prominently to notice during the period the report covered. These individual accounts are almost invariably grouped systematically and are in many respects models in their thorough, lucid, concise treatment of injurious species.

The series of reports and other entomological publications by the Federal Government was begun by Townend Glover in 1854 and has continued, with a few breaks, in one form or another to the present day. The work of Glover was seriously hampered and his reports, while containing a mass of valuable information, were far from what he would have made them had conditions been more favorable. It will be observed, however, that he evidently planned his work with the intention of ultimately reaching the desired end, no less than that of giving popular economic accounts of all of the more important groups of insects. For example, his report for 1867 is concerned largely with the food habits of beetles, that of 1875 with the Heteroptera, that of 1876 with the Homoptera, and of 1877 with the Hymenoptera.

His work was continued by the late Dr. C. V. Riley, of whom all of us know, and to whose writings coming generations of economic entomologists must constantly refer. Dr. Riley began his work in Missouri and his nine reports issued there from 1869 to 1877 have been characterized by Dr. Howard as forming "the basis for the new economic entomology of the world." These reports are original, practical, scientific, and include a multitude of facts and intelligent deductions which have had a potent effect upon the science. The work begun in Missouri was ably continued in the United States Department of Agriculture, with the exception of an unfortunate break of two years, down to the untimely death of this gifted scientist. His work in the Department of Agriculture was in many respects a continuation of that begun in Missouri, and the large amount of information gathered and published is most remarkable. The reports of this man are largely composed of independent accounts of various species coming prominently to notice from year to year. Dr. Riley's skill with the pencil and his accurate dilineation of insect life has added very materially to his reputation.

The later work of the Division of Entomology has been continued by one with whom we are well acquainted, and at present we will leave his work and turn to a consideration of other reports.

The magnificent series of volumes on economic entomology prepared by the State entomologists of Illinois contain an immense amount of information and will ever remain enduring monuments to their writers. There are special features in this series of reports which are worthy of mention. Dr. Le Baron began in his third report his Outlines on Entomology, which was continued in his fourth, and Dr. Thomas in the sixth report began a series of papers designed to form a popular account of the entomology of the State, particularly of those species of economic importance. His successor, Dr. Forbes, has given us several papers of noteworthy value. His twelfth report includes a discussion of the food relations of predaceous beetles, and the appendix to the fourteenth is an index to the twelve earlier reports. The fifteenth and sixteenth give much space to a detailed consideration of the chinch bug, and the seventeenth contains an analytical list of the entomological writings of Le Baron, and renders his work more accessible to other writers. The eighteenth report contains an admirable monograph on insects injurious to Indian corn, and the nineteenth is devoted largely to a monographic account of the work with chinch-bug fungus, the appendix comprising a detailed study of the Mediterranean flour moth by Professor Johnson.

The State entomologist of New Jersey has issued a series of reports since 1890 which contain a mass of original observations concerning insects injurious during the various years. These accounts are grouped under important food plants as a rule. Exceptional features are that his report for 1893 contains a brief general account of the more injurious species belonging to all orders, and that for 1895 an interesting and valuable paper on the Relation of Insects to Fruits. Later reports give much space to crude petroleum as a remedy for San José scale.

The late State entomologist of Minnesota, Dr. Otto Lugger, began a series of reports which promised, when completed, to form a remarkable contribution to the entomology of America. His second report treats of parasites of man and domestic animals, the third of the Orthoptera, the fourth of Hemiptera, the fifth of Coleoptera, the sixth of Lepidoptera, and it is stated that the manuscript treating of the Diptera[a] was nearly completed at the time of his death. It is certain that had this series of reports been carried to an end, America would have been favored with one of the best general works on practical entomology which has yet been issued.

The reports of the Entomological Society of Ontario, beginning in 1870 and extending to date, is a remarkable series of publications, replete with interesting and valuable observations by many writers upon the economic insects of that section. These reports, and those from 1884 to date, of Dr. James Fletcher, entomologist and botanist of the Central Experimental Farms, include most of our records concerning the insects of the northern part of America, and are composed largely of original observations and exceedingly practical recommendations and deductions from observed facts.

It will be seen from the above that the reports of various State entomologists differ widely one from the other, and that within certain limits at least a considerable choice is admissible. There has been of late years a marked tendency toward specialization, which is perhaps as well exhibited in the publications of the United States Department of Agriculture as anywhere. The report of the Entomologist, which was formerly a contribution of some 200 or 300 pages, has been cut down and comprises relatively few pages devoted to a general discussion of conditions. The entomological matter formerly appearing in the report has been subdivided and is made public either as special papers in the Yearbook or as bulletins treating of some special subject, which may be either economic or systematic. It seems to the speaker that generally speaking this is a step in the right direction. The general public is not interested in entomology itself, and will read bulletins or reports on the subject only when some practical end is served. It must, therefore, be approached from this point of view. The speaker has been impressed for some years with the idea that extended reports on entomology, while they contain a great deal of very valuable and useful matter, do not appeal to the public mind, and he is therefore inclined to think that wherever conditions will admit our publications should be of a special rather than of a general character. The annual report on entomology, wherever it is possible to have one, is a very convenient method of publishing observations and other records which could not be properly included in a bulletin, and such reports should have a limited circulation. They are more for the economic entomologist, the one who wishes to go back to original sources of information, and do not appeal to the general public.

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[a] Since reading the above Professor Washburn has informed us that he has failed to find any such manuscript, and if it ever existed it has probably been lost.

There are, however, special reports on well-defined economic groups, which are of greatest value to the general public and of utmost utility to the nation. I refer in particular to such works as Hubbard's Orange Insects, Comstock's Cotton Insects, the reports of the United States Entomological Commission on Rocky Mountain Locusts, and Dr. Packard's report on Insects Injurious to Forest and Shade Trees, and to the monographic report on the Gipsy Moth, by Messrs. Forbush and Fernald. These are the highest form of report, and, when properly prepared, constitute an exceedingly valuable record concerning species of great economic importance. Such works as these appeal not only to the practical or economic entomologist and the systematic worker, but also to every man interested in the crops or products affected by the insects treated. Such work as this adds very materially to the prestige of economic entomology in America, and will continue to do so just as long as the parties engaged in such efforts are well qualified and possess the high ideals governing those who have gone before.

BULLETINS.

Next to newspaper articles, bulletins appear best to reach the popular mind. The first important bulletin on economic entomology, so far as known to the speaker, is No. 1 by the United States Entomological Commission, which was issued in 1877, and which was followed by six others, five being devoted to popular accounts of specially injurious insects or groups of insects, and the other, No. 6, being a detailed index and supplement to the classic Missouri reports previously mentioned. This latter, therefore, in reality helped to render more accessible a mass of earlier published observations. This series of bulletins was closely followed and overlapped by a series begun under the authority of Dr. Riley, then chief of the Division of Entomology, United States Department of Agriculture, and continued through 33 numbers. This earlier series has been followed by a second series, which already includes 38 popular and 9 technical bulletins.

About 400 entomological bulletins have been issued in America by various State experiment stations and other public officials charged with the study of entomology, and the limited time prevents their discussion in detail. These publications, however, may be grouped as follows:

1. Popular brief accounts of individual insects or groups of insects of economic importance.
2. Monographic accounts of individual insects or groups of insects of economic importance.
3. Technical bulletins.

There are a number of advantages and some disadvantages in the use of bulletins as a medium for rendering information available. These publications are not so permanent in character and unless carefully bound by the recipient are liable to be lost or even worn out by constant use. On the other hand, the bulletin usually permits a much more prompt publication than is possible with the annual report and in addition allows a much more elastic grouping of matter. This of itself is of considerable value, particularly when publications are used, as many of us do use them, to answer queries in regard to this or that insect. If we have a bulletin treating only of the species involved, it will usually answer every question, while if we send a report, which may include accounts of a number of other insects, the treatment of the one under consideration may or may not be full enough to answer the requirements of the case; and an additional disadvantage in sending reports is that we may be obliged to transmit a mass of matter which has comparatively little or no interest to the recipient. The bulletin is therefore desirable whenever we wish to publish promptly and economically.

It is very difficult to define the scope and character of the popular bulletin. Generally speaking, it should be brief, concise, and contain very little more information than is necessary for the practical fruit grower or horticulturist who wishes to control the species in question in an intelligent manner. This means that many details, which are of considerable value to the systematic student and the biologist, must be rigidly excluded. These brief popular bulletins may, as previously mentioned, treat not only of one insect but of an economic group, and it seems to the speaker that the latter in the long run are bound to be more successful and beneficial. He has been informed, for example, that the excellent publication on Household Insects, Bulletin No. 4 (new series), Division of Entomology, United States Department of Agriculture, is very popular and that the demand for it is simply enormous.

There is another form of the brief popular bulletin which is exceedingly well represented in the circulars issued by the Division of Entomology. These, as we all know, are very brief accounts of individual species and are exceedingly useful in answering queries from time to time. Such circulars are abridged from fuller accounts, and this form of publication has been used by a number of entomologists with a great deal of success.

Another device for the popularization of scientific matter has been adopted by the New York State agricultural experiment station at Geneva and consists in prefacing every bulletin by a very brief synoptic account of its contents, and, in not a few instances, there is a popular edition of the bulletin as well as an extended one. This popular edition is very little different from a circular treating of an individual species except that the popular bulletin includes the same field as the more extended publication, whether that treats of a single insect or a group of insects.

Monographic economic accounts of insects are exceedingly valuable, and are absolutely necessary to the advancement of the science. Recent years have witnessed the issuing of a number of noteworthy publications of this character, among which may be mentioned Slingerland's account of the codling moth, Card and Gillette's studies of the same insect, and other bulletins of a similar character. In such publications as these, we should have a summary of all that is known, together with a mass of original information. This work is absolutely necessary, and probably the best method of making it public in the majority of cases is by the use of the bulletin. These bulletins, however, must of necessity be published at irregular intervals, and therefore can have little connection one with the other.

This scattered method of publication has serious disadvantages and the monographic accounts of economic groups are designed to remedy this evil. We have a number of noteworthy publications illustrating this line of effort, among which may be mentioned Forbes's excellent account of insects injurious to indian corn, Forbes and Hart's economic entomology of the sugar beet, Slingerland's climbing cutworms, and others of like character. Such publications appeal to the popular mind because, as a general rule, they approach the subject from the aspect of the practical grower, and are of more general service than the detailed monographic accounts of individual insects.

The technical bulletin is a publication of entirely different character and is, or should be, designed almost solely for the use of the economic worker and not for the general public. These bulletins are usually issued in limited editions and sent only to those who can use them to advantage. They may be and frequently are largely systematic in character and should include monographic accounts of considerable economic importance on such subjects as parasites, leaf feeders, borers, etc. Excellent representatives of these are seen in Howard's Study of Insect Parasitism, Marlatt's account of Nematinæ of North America, Coquillett's Revision of the Tachinidæ, and Hunter's Aphididæ of North America. Such works as these, though frequently embodying much systematic and biologic work which apparently has no direct bearing upon the practical aspect of economic entomology, are absolutely necessary as a basis for further work. These more technical studies are in reality of equal if not greater value in developing economic entomology than the more popular practical accounts which are prepared for the general public. It is true that they are accessible to and read by fewer individuals, but these individuals are the parties who prepare the popular accounts and make free use of the more technical matter wherever it can be employed to advantage, so that in reality the public receives full benefit from any such publication.

JOURNALS.

The various entomological journals published from time to time contain more or less economic entomology, only one of which can be mentioned at this time. The economic department in Entomological News, conducted by Dr. J. B. Smith, was instituted a number of years ago by Dr. Skinner, and affords an opportunity for the prompt publication of shorter articles and is a valuable feature of the periodical. There are three journals which have been devoted entirely to economic entomology. The Practical Entomologist, which ran through two volumes, and the American Entomologist, which completed three, are the only instances of publications supported in part at least by subscriptions which have been devoted very largely to economic entomology. The shortness of their lives is eloquent of their lack of support. A unique serial, devoted entirely to economic entomology and independent of subscribers, was issued by the Department of Agriculture under the joint editorship of the late Dr. Riley and Dr. L. O. Howard and is well known to every worker in the science as "Insect Life." There is perhaps no other publication which contains so much original information concerning entomology within so limited a space as these seven volumes. The numbers were issued approximately monthly. The editor was the Chief of the Division of Entomology, and as he was supported by an able staff of assistants, not to mention the entomologists of the entire country, there was nothing in the publication which was not reliable, and the effect upon the development of the science was extremely beneficial. It afforded a ready medium for the announcement of interesting and valuable discoveries and received the hearty support of every worker in the science. The monthly issue of the numbers kept every entomologist informed regarding the doings of his associates and served as a general stimulus to all. We can but regret that it was necessary to discontinue such an admirable publication, and while its loss is in part made good by the most excellent series of bulletins issued by the Division of Entomology, still there are features in the periodical which have not been, and probably can never be, made good by the issuance of bulletins at irregular intervals. This series of bulletins can never command such a general support of working entomologists as a publication issued at regular intervals, and consequently, with the discontinuance of Insect Life, economic entomologists lost a ready means of communicating one with the other, and the speaker feels that the development of the science has been hindered by its suppression. A publication dependent upon subscription can never fill the place occupied by Insect Life, since it must cater to its readers and give considerable space to well-known facts, whereas a publication independent of subscribers can follow a definite plan and restrict its matter to that which is original or of great value on other accounts.

GENERAL WORKS.

There are several general works on economic entomology which have been published, aside from reports and other official publications by State or station entomologists. One of the earliest and the best in a great many respects is Saunders's Insects Injurious to Fruits. The injurious species are grouped, according to the part injured, under important food plants. Each account, while brief, gives a résumé of the more important facts concerning the species.

The early edition of Professor Saunders's work was closely followed by Cooke's Injurious Insects of the Orchard, Vineyard, etc., a work which covers the entire field of economic entomology in less than 500 pages. The treatment of each species is necessarily brief, and while the accounts are grouped according to food plants the systematic position of a species and its synonymy are indicated. The work was prepared particularly for the use of fruit growers and vineyardists in California, where it appears to have found its principal sale.

Dr. Weed's Insects and Insecticides (1891) treats of the more important injurious insects and methods of controlling them in a volume of less than 300 pages. The limited space made a rigid selection imperative, and the account of each species is brief. It is an exceedingly valuable work, and the following year was followed by Kellogg's Common Injurious Insects of Kansas, which covered the same field as the preceding work. The treatment is a little different, and a feature worthy of special mention is the brief diagnosis preceding the account of each species. Dr. Smith's Economic Entomology (1896) is a work prepared along very different lines from the preceding, and gives brief practical accounts of all the more important injurious insects within the limits of 466 octavo pages. The various accounts are necessarily limited and the arrangement is systematic, a discussion of the injurious or beneficial species of the different orders being preceded by a brief account of ordinal and family characteristics.

The same year The Spraying of Plants, by Lodeman, appeared, and while the scope of the work is greater than that of entomology, much of the latter is included. The most prominent characteristic of the volume is its great condensation, more facts being included within its 400 pages than perhaps in any other volume of its size.

The present year has been marked by the appearance of Fumigation Methods, by Professor Johnson, a monograph of the application and uses of hydrocyanic acid gas, and by the publication of Sanderson's Insects Injurious to Staple Crops, which latter is prepared on somewhat similar lines to Saunders's Insects Injurious to Fruits and covers its field more fully than has hitherto been done.

INDEXES.

The literature of American economic entomology has become so extended that detailed indexes are an absolute necessity; otherwise many valuable records are lost, so far as the busy worker is concerned. The first general index published was that to Riley's nine Missouri reports, and in many respects it is a model publication. It is not only very detailed, but every insect is indexed by its specific as well as its generic name, something which the speaker is inclined to think of great importance. The many changes in nomenclature make it very difficult for a person to keep up with them, and the index which lists a species by its specific as well as generic name aids materially in this respect. This publication is perhaps open to one criticism, in its having separate indexes for plants and insects. This is to some extent a matter of taste, and yet the speaker is inclined to believe that the general index, including all references, is superior, since no question can arise as to which index is before the seeker for information. This is something which used to trouble my distinguished predecessor not a little and my hearers are probably aware that all the later indexes prepared under his direction have included every reference.

The next general index to appear was that by Professor Forbes of the first twelve reports of the State entomologists of Illinois. This is prepared on very nearly the same lines as that to Riley's Missouri reports, and is also open to the criticism of having separate indexes for plants and insects. It is, however, admirably gotten up and has proven of great value to working entomologists, since it renders more accessible the vast amount of information recorded in these reports.

Neither of these general indexes, or the later one prepared by Dr. Lintner, have aided in making accessible the vast amount of information annually published in newspapers, bulletins, reports, or other publications by the economic entomologists of America. This literature is widely scattered, and the preparation by Mr. Henshaw of a bibliography of the more important writings of Messrs. Walsh and Riley made way for general indexes to the publications of other American writers on economic entomology. My hearers are all familiar with the admirable series of bibliographies prepared under the auspices of the United States Department of Agriculture, Division of Entomology, which have rendered this vast literature accessible to economic workers. It is only a question now of consulting a few indexes, and the average worker, if he has an adequate library at his command, can easily learn what has been recorded concerning injurious species under consideration. If one were to criticise these publications at all, it might be allowable to suggest that the indexes be made a little more detailed, particularly in the later publications. The addition of references to specific as well as generic names and to food-habit records would materially increase the value of the volume without greatly extending its limits.

The general index to that magnificent series of volumes known as "Insect Life" has proven an invaluable publication to almost every economic worker, and our hope is that in the future we will see more such aids to research.

Indexing is to some extent a thankless task, and yet a very necessary one if we would keep abreast of the times. The value of the index lies not in its length, but in its usefulness, and the speaker has always felt that it was by all means advisable to index all important references, at least, under several names, wherever that could be done with propriety. No two men think alike, and an index should be made for the use of all. Some approach a subject from one side, others from another, and unless the index is general enough to include all it is liable to be comparatively useless to a great many. The speaker is of the opinion that the general index should include, as previously stated, references to generic, to specific and common names, to food plants; and every index of a series of volumes should also include illustrations, preferably under a general title, such as figures, because it sometimes occurs that a worker is searching for a good illustration, and if by turning to a few general indexes and looking under figures he can find where all such have been published it is an immense aid.

It is impossible to lay down any fixed rule as to what references shall and what shall not be included in an index. This depends somewhat upon the character of the work. In general, the speaker believes that every isolated fact not specifically included in the title of the publication should appear in some form in the index, if the object of the index is to make accessible the contents of the volume. The speaker is gratified to observe that some of our more recent bulletins are being indexed, and while there are undoubtedly publications of this character where an index is superfluous, in a great many instances it is of decided value and should be incorporated wherever circumstances permit.

A table of contents is also of much value and adds considerably to the completeness of any publication. It need not be an extended one unless the work requires it, because a very brief summary may include everything that is desirable. It is not necessary to devote an entire page to the table of contents and the speaker can not but commend to his hearers the plan of the university of the State of New York of placing on the cover page of its bulletins a brief summary of the contents. It requires little space, is conspicuous, and usually meets every requirement.

The above discussion of the various forms of publications and the purposes which they serve has been entered into because the subject is one of prime importance, and while undoubtedly each of us has given the matter consideration before, it may be that a joint discussion will bring out facts of value. The speaker recognizes the limitation imposed upon various entomologists and is well aware that it is not always practicable to choose between different forms of publication. Each institution usually has certain methods which have become established through years of usage and there is more or less difficulty in securing a change. The advantage of discussing the matter on this occasion is that whenever a change is possible we may know how to use it to the best advantage. The ideal scheme of publication, it seems to the speaker is about as follows:

1. Newspaper articles.
2. Brief popular circulars.
3. A little more extended but brief popular bulletins, treating of economic insects or groups of insects.
4. Monographic popular accounts of economic insects or groups of the same.

It seems to the speaker that if the science is to be advanced in the future more attention should be paid to monographic accounts of economic groups. These should be extended enough to include most of the forms of importance, and at the same time give references to more detailed accounts of each species or group of species, so that the student more deeply interested in the subject can continue his studies further.

5. Reports containing records of activity and such other matter as can not be conveniently grouped in a bulletin or special treatise.
6. Technical bulletins or systematic accounts of natural groups of greater or less importance.

We all recognize the fact that systematic and economic entomology can not be separated one from the other. They are joined together by bonds which no man can sever. Many of the groups of insects are of considerable economic importance, and the speaker is of the opinion that he who will work out a synopsis of any such group is doing much to advance the science of economic entomology. We are to-day hampered by the fact that it is extremely difficult for the beginner to recognize injurious species, or for the one more advanced to determine many forms which may be brought to his notice on account of unusual depredations. This difficulty can not be overcome till every group having any economic importance has been carefully treated in a systematic way, and if this account also includes a brief general discussion of the economic importance of the groups, subgroups, and possibly even genera and species, together with references to the more important literature treating of each, we have at our command a series of works which would be of the greatest value to all subsequent students of economic entomology. Such works as these would necessarily be very concise, and yet, if properly arranged and with well-selected references, would prove of utmost value not only to systematic, but to economic workers, and would also be exceedingly helpful to all having even a general interest in the groups treated. Dr. Lugger's reports are an approach to this ideal, but it seems to the speaker that such accounts might well be more detailed and should include, as nearly as possible, every species in the fauna; and that the value of such treatment would be immensely increased by the addition of bibliographic references as mentioned above.

Reference has been made to the close analytical study of our economic publications by Dr. Forbes, and the speaker can do no better than bring his remarks to a close by quoting this talented scientist, as follows:

> It is not the wealth one gathers, but that which he puts to use, which makes him rich. It is not the knowledge we acquire, but what we succeed in making application of, which makes us wise. It is not the facts of entomology we discover, but those which we persuade the farmer, the gardener, or the fruit-grower to use diligently for the protection or the preservation of his crops, which make our entomology economic. To discover without publishing effectually is to waste our time as servants of the public. To publish valuable results without making sure of their appreciation and appropriation by our constituents, is to fail of real usefulness and the reward of usefulness. To bring a result to bear on the practice of one man only when a thousand are suffering for the want of it, is to fail in 99.9 per cent of our proper undertaking. We must first do exact, exhaustive, conclusive, practical economic work, and then we must find means to get that work utilized or it is an economic dead loss.

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University of the State of New York

BULLETIN

OF THE

New York State Museum

FREDERICK J. H. MERRILL, *Director*

VOL. 6 No. 26

APRIL 1899

COLLECTION, PRESERVATION

AND

DISTRIBUTION OF NEW YORK INSECTS

BY
EPHRAIM PORTER FELT, D. SC.
State Entomologist

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PREFACE

The organization of a corps of voluntary observers makes it necessary to issue directions for collecting and shipping insects. It is believed that the chapter on the distribution of insects will be a valuable guide in directing observations along lines hitherto largely ignored. This bulletin has also in view the guidance of pupils who, for a small compensation, may undertake to collect insects for the state. It was thought best to include directions for preserving insects, in order to encourage younger students to build up collections of their own.

No claim is laid to originality in the text of this bulletin, as available sources of information have been freely consulted. The illustrations are all original, having been prepared under my direction by my assistant, Mr C. S. Banks.

EPHRAIM PORTER FELT
State entomologist

COLLECTING INSECTS

With a little experience it is usually easy to collect insects very successfully, provided one gets rid of the notion that the more common forms are unworthy his attention. I have repeatedly seen students who were required to make a collection, spend more time begging insects than it would take to catch them. A beginner must be content at first to take those he can see, and then as eye and muscles become trained, he will soon be able to secure those of greater value.

Collecting bottle. First provide at least a collecting jar or bottle. For most insects, except the larger ones, a wide-mouthed vaseline bottle is very convenient, but certain butterflies, moths and other insects with a considerable wing-spread should be put in a larger bottle or jar with a proportionately wider mouth. In order to prevent specimens from injuring themselves, the jar should be charged with potassium cyanide, but as this is a deadly poison it must be handled with care and the bottles might be more safely prepared by a druggist or teacher. The usual method is to put in the vaseline bottle two or three pieces of cyanide about twice the size of a pea (more if a larger jar is used), pour in just enough water to cover the poison, and then add at once enough plaster of paris to take up the water. With a cloth wipe out the upper portion of the bottle and allow it to stand uncorked till the plaster has hardened and the inside is dry. Then cork tightly, label the bottle **Poison,** and in a few hours it will be ready for use. Do not have the bottle open more than is necessary as the cyanide loses strength rapidly. Those afraid of this dangerous substance can add chloroform to a little cotton kept in place by a disk of blotting paper and use that in the collecting bottle. But as chloroform requires frequent renewal and is not so deadly to insect life, the cyanide bottle is generally preferred, and with reasonable care need not be feared. With no farther outfit many insects can be captured by advancing the open bottle and partly pushing and partly driving the specimen in with the cork. A little

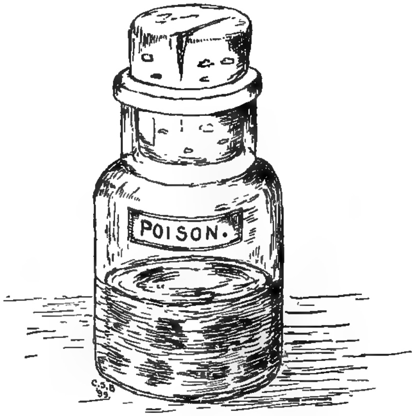

FIG. 1 Collecting bottle (original).

practice will be found necessary before the more wary species can be taken in this manner.

Insect net. Those wishing to secure butterflies, moths and other rapid flying insects will have much use for a net. This may either be bought or made at home. It consists of a stout handle, a broom handle about 1 meter ($3\frac{1}{2}$ ft) long will answer, to which is securely fitted a $\frac{1}{2}$ cm ($\frac{3}{16}$ inch) wire ring 30 cm (about 12 in.) in diameter, bent as indicated in figure 3 and firmly held by a ferule. The ring can easily be made and attached by a tinsmith or blacksmith. The net itself should be a little shorter than the collector's arm, preferably of cheese cloth and firmly sewed to a thicker band around the ring. The bottom of the net may be cut square, forming two corners, or better, cut round or into four angles and brought down to a point, as represented in figure 4, thus doing away with corners which are apt to be troublesome. Those wishing a nicer article can buy of dealers in entomologic supplies various styles of nets ranging in price from $1 to $2.50. For $1.50 a very desirable net with jointed handle and folding frame can be secured. When using the net approach the insect cautiously and with a quick swing and turn of the handle it is captured. It does not pay to chase insects. Transfer captures directly from the net to the cyanide bottle, as the less insects are handled the

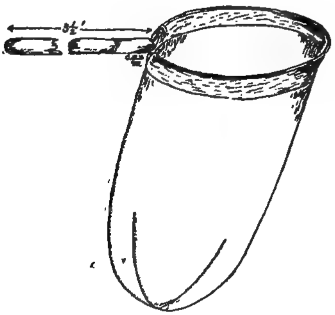

Fig. 2 Butterfly net (original).

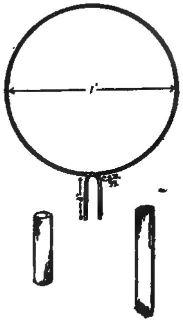

Fig. 3 Details of net rim (original).

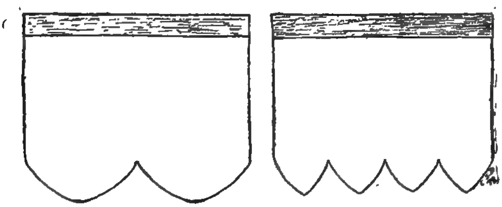

Fig. 4 Patterns for net bottoms (original).

greater their value. Usually it is comparatively easy to place the open bottle over an insect in the net and induce it to enter without touching it.

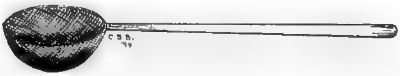

FIG. 5 Dip net (original).

Those wishing to collect water insects will find a shallow net of coarse material much more convenient than the ordinary butterfly net, because the mesh of the latter is too fine to permit moving it rapidly through the water.

Collecting box. Those interested in butterflies and moths will find a collector's box of great service. This is a flat box just deep enough to hold pinned specimens and having a layer of cork on the bottom. It may be made specially, or a cigar box of convenient size for carrying may be utilized. Some collectors merely attach a short piece of leather with a buttonhole in the free end, and when in the field the box hangs from a convenient button. Others use a strap swung over the shoulder.

Folded papers for butterflies. Butterflies may be killed in the net by pinching the thorax between the fingers, taking care that the wings are folded back before touching the insects. They are then placed in papers as represented in the accompanying diagram, the slip being proportionate to the size of the insect, and the locality and date placed on the outside. Specimens may be sent through the mails without injury in such papers.

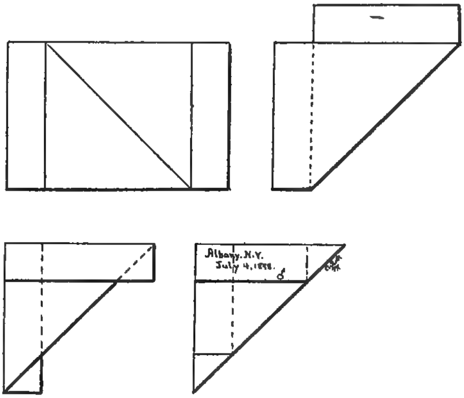

FIG. 6 Method of folding butterfly papers (original).

Vials and small boxes. It is well to carry on a collecting trip a number of vials and small boxes in which insect eggs, larvae, etc., with a little of their food plant, can be kept for closer examination later. For soft bodied insects several of the vials should contain 50% alcohol.

Capturing insects. The beginner will soon learn that certain localities are more productive than others and that the time of day has considerable influence on insect activity. It would be well, though by no means necessary, to take the first trip or two on bright warm days in company with one who has done some collecting, and plan the course so that diversified country will be traversed. Insects may be found in almost any place, but experience will soon teach the most favorable localities. At first take everything, thus training eye and muscle, and learning a little of the varied forms of life. The collector will soon find that beetles, bugs and other insects can not be put in the same bottle with certain forms without becoming covered with scales, and if ambitious to secure nice specimens, he will have a special bottle for butterflies and moths. Dragon flies are also best kept in a large bottle by themselves. Large insects injure the smaller ones and it will be found that numbers of water insects can not be put in with others without injury to many of the more delicate terrestrial forms. Hence, the necessity of treating collected insects differently, and the immense number of forms to be studied, will soon compel specialization to a certain extent. That is, all those belonging to one order, as the butterflies and moths, the beetles, etc., or those attacking a few related plants or occurring in certain localities will be collected in preference to all others, and in this way many valuable facts are ascertained, which would be impossible were general collecting continued indefinitely, and at the same time much pleasure may be derived from the pursuit.

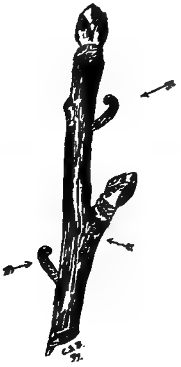
Fig. 7 Pistol case bearer (original).

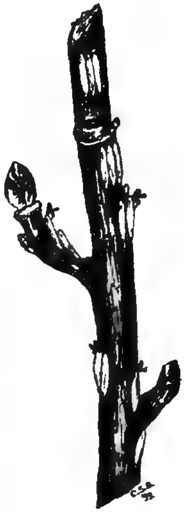
Fig. 8 Cocoons of apple Bucculatrix (original).

The actual method of procedure can hardly be described. In a general way walk rather slowly, pausing to examine a cluster of flowers, to look under stones, to examine the trunk and branches of trees, rotting wood, etc. After a little practice it will be surprising to see how many species on flowers can be taken with nothing but the collecting bottle. Many insects belonging to the bee and wasp family, some very handsome beetles, interesting members of the true bug family and a few flies can be captured in this manner. As some beetles and bugs drop readily to the ground, the bottle should be held a little below the insect. Dark colored, rapid running ground beetles may be found under stones and will require quick work to catch them. Trunks and branches of trees repay a careful examination. On the smoother bark, sometimes hardly visible, there may be scale insects sucking the vital fluids from the tissues beneath, while numerous forms take shelter under loose edges of the rougher bark. Caterpillars of various kinds may be found crawling on the trunk or resting on the smaller twigs and sometimes resembling their support so closely as to require a practised eye to detect them. In winter and early spring the peculiar case bearers, the cocoons of the apple *Bucculatrix*, and the more concealed winter retreats of the bud worm can be found only by close inspection. Then there are the eggs of various species, some times in clusters on the bark or even in belts around the limbs, as in the case of the apple and forest tent caterpillars. Minute particles of sawdust hanging from a slender thread or lying at the base of the trunk indicate the presence of borers. In a similar manner examine the foliage quietly and carefully. Various larvae, some moths, leaf-feeding beetles, bugs, etc. may be found and by holding the net or an inverted umbrella under a bough and beating it with a stick other good specimens can be obtained. When it is remembered that 371 species of insects are known to attack the apple tree or its fruit in one way or another, some idea will be obtained of the possibilities in collecting. Every part of a tree — root, stem and branch, flower, leaf and fruit — will repay examination. A person who will take one plant and study thoroughly the insects occurring thereon throughout the year can hardly avoid making a rich contribution to the world's fund of knowledge.

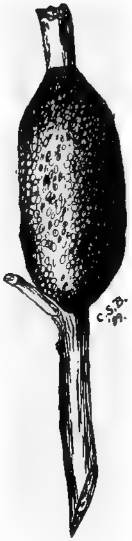

FIG. 9 Egg belt of apple tent caterpillar, enlarged (original).

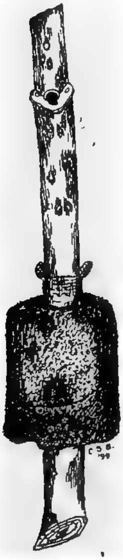

FIG. 10 Egg belt of forest tent caterpillar, showing a few exposed eggs, enlarged (original).

The insects inhabiting a meadow, those living in sandy places, aquatic or alpine forms, all offer inviting fields to the student of nature, and in each the collector will find much of interest. In meadows or grass land and other places where there are not too many obstructions, sweeping with the net results in the capture of many species. The collector advances across the field swinging his net vigorously to one side just above the herbage, or even hitting the taller plants, and at the end of the stroke turns the net quickly and reverses the movement, thus producing a continuous sweep which is maintained till considerable material is taken. The desirable specimens are then removed from the net and the operation continued. In sandy places the fauna is rather scantily represented by ground beetles, tiger beetles, grasshoppers, etc., requiring closer search to secure many forms. Among the more interesting insects are those inhabiting water. Caddice fly larvae with their peculiar cases may be found at the bottom of streams and ponds; on the under sides of stones the curious larvae of stone flies occur; among weeds and decaying matter the strange water scorpion moves slowly, its long legs and slender body suggesting the walking stick, which is, however, a very different insect. In ascending a mountain a good idea of the effect of climate is obtained by a study of insects. As the altitude increases certain species become less abundant and forms relatively scarce in the lower regions begin to appear in numbers. A striking example of this is seen in the arthemis butterfly, *Basilarchia arthemis* Drury, a northern insect with a range closely limited by the southern boundary of New York state. In the lowlands it is relatively scarce, while in the higher regions near and in the Adirondack and Catskill mountains it abounds on account of the more congenial climate. At a moderate altitude insects are numerous but they differ in species from those below, and at extreme hights the fauna becomes scanty with an increase of wingless species. The latter peculiarity is also noticeable on smaller islands and may be explained by the strong winds of such places carrying away flying insects and thus favoring wingless forms.

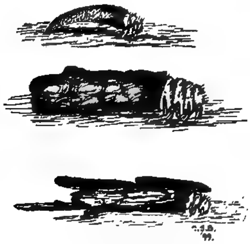

FIG. 11 Caddice fly larvae and cases (original).

Collecting at lights and sugaring. The attraction light has for insects is well known, and is frequently taken advantage of by collectors, who secure valuable specimens in this way. In many places all that is necessary is an open window in a lighted room. Dark, warm nights accompanied by rain are usually the most productive. In cities the electric arc lights attract many insects and may be visited with good results.

Examples of the family Noctuidae or owlet moths (many are known to the farmer in the larval state as destructive cutworms) can probably be secured in no better way than by sugaring. This consists in smearing a mixture of sugar and vinegar on the trunks of a number of trees or on fences in a favorable locality. Stale beer added to a mixture of sugar or molasses and water makes a very effective preparation. The bait is applied at dusk to a number of places, and each desirable specimen is taken with the aid of a light by placing a wide-mouthed cyanide bottle over it while feeding. The moth will usually enter the bottle at once or can be induced to do so by a slight lateral movement of the poison jar, and then the cork can be replaced. If it is a good night, the collector will need at least two cyanide bottles in order that dead specimens may not be injured by later captures, the moths being transferred to the second jar as they become quiet.

Immature forms. Collecting insects in the pupa or quiescent stage is a ready means of securing perfect adults. Aside from rearing caterpillars, this is the only method of obtaining the more perfect examples of butterflies and moths, and is quite extensively practised. Cocoons may be found hanging from limbs, particularly on the lilac, lying on the ground enveloped in leaves, or securely tucked in many a sheltering crevice of tree, stone and fence. A large number of caterpillars enter the ground to a slight depth and transform in rude earthen cells. It is not difficult to find pupae in the soil, particularly in forests. They can be obtained in large numbers in fields where army worms have been abundant.

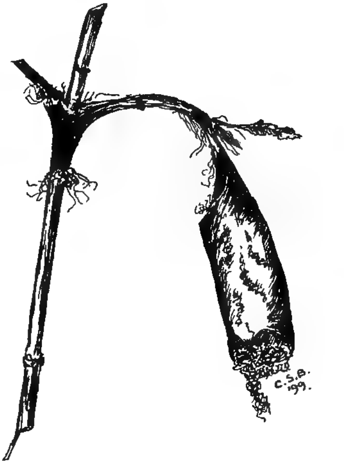

FIG. 12 Promethea cocoon on lilac, slightly reduced (original).

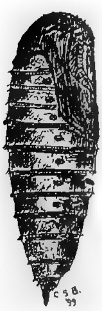

FIG. 13 Pupa of imperial moth (original).

Most collectors pay exclusive attention to the adult insects, and only in the exceptional cases of a few well-known forms are caterpillars considered worth bothering with. As we unfortunately know comparatively few insects in their adolescent stages, this has stood in the way of their study, specially as larvae are rather difficult to preserve nicely and only in the hands of the skilful can be made attractive. Nevertheless the collection and study of immature forms, notably caterpillars, offer a very inviting field to one who delights in the unknown. Their habits, adaptation to conditions, protective coloring, etc., are very interesting and profitable lines for inquiry, and when larvae of all orders are included, the student has before him an exceedingly rich field. It is nearly impossible to find a place in nature that is not capable of supporting insect larvae. They may be found devouring the entire substance of leaves, eating only the softer under portions or even mining between the upper and lower epidermis. They closely simulate the appearance of a twig, bore within it or the trunk, inhabit all manner of vegetable matter, food stuffs, etc., are found in the alkali lakes of the west and one species is known to live in crude petroleum in the vicinity of oil wells, showing to what a wonderful extent the various forms of life can adapt themselves to conditions.

PRESERVING INSECTS

Most insects can be preserved by pinning and drying, but to attain the best results it will be necessary to have a few supplies and to follow certain tested rules.

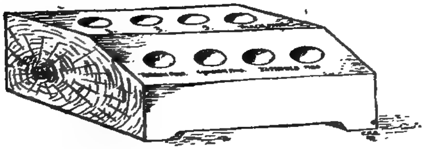

FIG. 14 Block for holding pins (original).

Insect pins. Entomologists prefer insect pins made specially for this purpose. Those most extensively used in this country are from 3.5 to about 4 cm ($1\frac{3}{8}$ to $1\frac{5}{8}$ in.) long, are more slender than ordinary pins and are made in several sizes, the more convenient being nos. 1, 3 and 5 of the Kläger pins, no. 3 being the best if but one size is used. A convenient means of keeping several sizes and kinds of pins is a light block of wood about three fourths as deep as the pins are long with a 2-centimeter (nearly $\frac{1}{2}$ in.) hole for each size of pin. Kläger pins or those of other makes may be obtained from dealers in entomologic supplies. A black japanned pin is preferable to the unprotected or white pin as there is less liability of verdigris spoiling the insect. The trouble with the black pin is found in its lack of stiffness, specially in the smaller sizes.

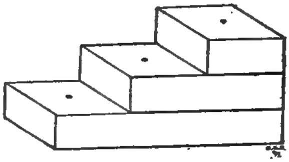

FIG. 15 Pinning block (original).

Pinning block. For the best appearance of the collection the insects should be fixed on the pins at a uniform hight. The beginner can accomplish this most easily by using a pinning block, a small piece of wood with a thickness equal to one fourth the length of the pin and with a hole through it large enough to admit the pin head. When mounting, thrust the pin nearly through the insect and then push it back to its proper place by reversing the specimen and sticking the head of the pin through the hole in the pinning block. If desired, labels and insects mounted on points can be fixed at uniform hights by using a pinning block composed of three pieces one fourth the length of the pin, and with holes through the center of each step. The lower one can be used for spacing insects and labels, the second one also for labels and the third for small insects on card points.

Rules for pinning. Many entomologists prefer to have about one fourth of the pin above the specimen, and this can be secured easily by using the pinning block described above. Experience has taught that not all insects can be pinned alike with the best results. As a rule the pin is thrust through the middle of the thorax, care being taken to have the insect straight on the pin. Among beetles however this procedure would result in spreading the elytra or wing covers and would produce very unsightly specimens. The rule for this large family is to put the pin through the right elytron or wing cover. Examples of the suborder heteroptera, or the true bug family, are usually pinned through the scutellum, the triangular piece near the base of the wings.

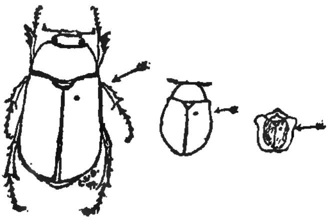

FIG. 16 Method of pinning beetles (original).

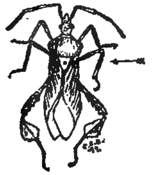

FIG. 17 Method of pinning true bugs (original).

Spreading apparatus. Butterflies and moths require some arrangement before they are fit for the cabinet. As taken from the bottle or papers and pinned, the wings are but partially expanded and frequently so folded that but few of the markings can be seen. This is remedied by the spreading board, composed of two boards with a crevice between large enough to admit the body of the insect, and having below the slit a strip of cork through which the pin holding the insect is thrust. The boards and cork are held in place by end and middle pieces. The points of the pins extending through the cork should be protected by a light strip underneath. Spreading boards are made in various styles and sizes to give sufficient room for the body and ample space for the wings. Three very convenient sizes have widths of $4\frac{1}{2}$, 8 and 11 cm ($1\frac{3}{4}$, $3\frac{1}{2}$ and $4\frac{1}{2}$ in.) with body spaces for the insects of 3, 6 and 10 mm ($\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{8}$ in.) and have a uniform length of $44\frac{1}{2}$ cm ($17\frac{1}{2}$ in.). Many prefer to have the wings spread exactly horizontal and others insist on a slight upward slant in order to counteract the natural tendency of the wings to droop after the specimens are removed from the boards.

A spreading pin is a great convenience and may be made by twisting with pliers a large beheaded insect pin tightly around and near the point of a large mourning pin in such a manner that the two form a right angle. The mourning pin is stuck into the board at a slight angle so that the smaller pin is held down on the insect's wings like a spring and prevents their flying back after being put in position. Narrow strips of paper held by pins at each end may be used in a similar manner.

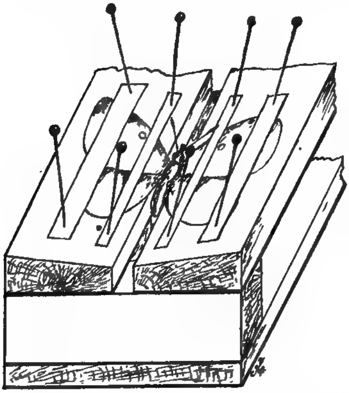
Fig. 18 Portion of a spreading board (original).

Directions for spreading. The pin is pushed through the cork till the wings are on a level with the board and the legs are arranged. Then take a setting needle and bring the wings of one side into position, holding them there either with a spreading pin or a narrow strip of paper. In a similar manner place the wings of the other side, having the posterior margins of the fore wings as nearly as possible on the same straight line, taking special pains to have the wings of each side uniformly advanced. Secure them in place with broad strips of thin cardboard or preferably thin pieces of mica. Arrange the antennae and after the board is full put it away and allow the insects to dry for several days or a week. Another method of spreading requires still less material. The pin sustaining the insect is thrust through the pasteboard bottom of a small inverted box and squares of pasteboard or thin wood of ample size are laid on either side in such a manner as to be of the proper hight. With a needle arrange the wings on the squares of pasteboard so far as possible and hold them in place by laying on small pieces of glass. By tipping up one edge of the glass considerable rearrangement is possible, or by pushing the lower block gently, wings and all may be moved either forward or backward. This method is capable of producing very good

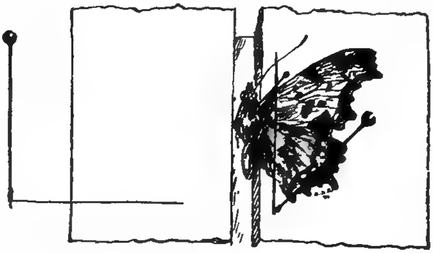
Fig. 19 Spreading pin and method of use (original).

results but the setting board is preferred by many. In spreading butterflies and moths the greatest care must be exercised not to rub off their scales. Members of the bee and wasp family, dragon flies and others are more valuable after spreading and should be so treated when possible.

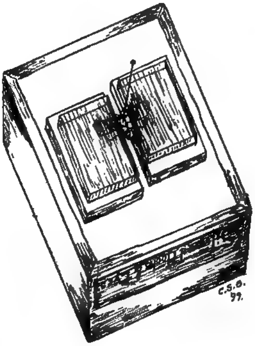

FIG. 20 Moth spread on pasteboard box (original).

Relaxing insects. From one cause or another it frequently occurs that insects become dry and brittle before they can be permanently arranged. In this condition no spreading is possible without serious breakage. If the specimens are put on paper or a piece of cork in a closed jar with moistened sand or a damp sponge and allowed to remain from a day, in the case of very small insects, to several days for the larger forms, they can be spread very well. The specimens should not be left in the jar too long or they may be spoiled by mold. A few drops of carbolic acid will aid in preventing fungus growths.

Denton's tablet. A pretty way of mounting butterflies and moths, specially for display, is in Denton's tablets, which are blocks of plaster of paris with a depression for the body of the insect and with paper strips for hermetically sealing the glass covers. As the glass rests upon the wings, they are held perfectly flat and the cover affords protection from dust and museum pests. Specimens thus mounted are said to be less affected by exposure to light. The tablets are sold at a moderate price and directions are supplied with each lot.

Treatment of small insects. Many insects are too small to be mounted, even on the most slender long pins. One of the easiest ways of caring for minute specimens is to mount them on card points, which are triangular pieces of card, cut either with scissors or with a punch designed for the purpose. An insect pin is thrust through the base of the card point and the specimen attached to its extremity with a little shellac or gum. Or a fine pin may be taken, its head removed, the pin bent to a right angle, the larger end twisted with pliers tightly around a stouter pin near its point and pushed farther up on the supporting pin, and the specimen impaled on the upturned point of the smaller pin. Another way of accomplishing the same end is by cutting off the larger portion of the smaller pin and thrusting the point through a piece of cardboard or firm blotting paper, which in turn is mounted in a similar manner on a larger pin, and is then ready for the insect. Small species can also be put with labels in gelatine capsules through one end of which a pin is run.

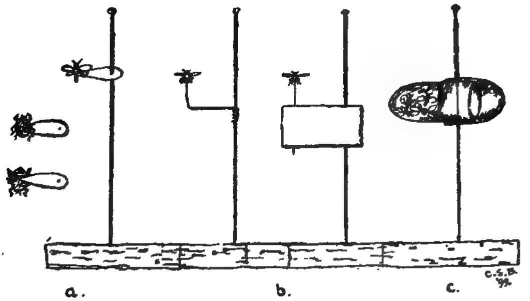

Fig. 21 Mounts for small insects. *a*, on card point; *b*, on pin point; *c*, in a gelatine capsule (original)

The collector frequently secures a large number of very small insects belonging to a single species. It would take much time to mount these as described above and yet they should not be thrown away, because such material may be desirable for later study. They may be preserved in alcohol or placed in vials and allowed to dry before corking in order to prevent mold. In a similar manner very desirable material taken at one time may be stored under a common label till there is leisure to arrange it, as the specimens have only to be relaxed before final mounting.

Inflating larvae. The caterpillars of many butterflies and moths can be well preserved by inflation. The specimen is killed in a cyanide bottle, laid on a piece of blotting paper, pressed lightly with a pencil, and the partially protruding intestine ruptured with a needle or a pair of fine forceps. Then lay the pencil crosswise just back of the caterpillar's head and roll it lightly toward the posterior extremity. This will force out the body contents, the process being aided somewhat by removing the intestine with forceps. The rolling must be done very carefully and in many cases repeated once or twice. If undue pressure is used or the pencil allowed to slip, hairs may be lost, the skin bruised and the specimen ruined. In the posterior extremity of the empty skin insert a pointed glass tube or blowpipe, to which is attached a short rubber tube, and fasten the caterpillar skin firmly with collodion, glue or a spring clip. If the blowpipe is inserted so as to distend the posterior opening, withdrawn, heated and inserted again, the skin will usually adhere firmly to the blowpipe. Keep it distended by blowing and at the same time dry by holding it near a lamp chimney or other source of heat. The skin must be dried till rigid, but burning must be carefully avoided. Some caterpillars bear inflation very well, specially certain highly colored ones, but it is exceedingly difficult to obtain nicely inflated green larvae.

More elaborate apparatus can be employed if desired. Some use pneumatic bulbs for forcing the air into the larval skin, but human lungs permit a more delicate adjustment to needs. A lamp chimney can be placed nearly horizontally over a source of heat and serve as a drying oven, or one may be constructed of tin. The latter is by no means necessary and a busy worker will soon depend only on a blowpipe and a convenient lamp It is well for the beginner to secure a number of rather large common larvae and practise on them. After a caterpillar is well inflated, it must be removed carefully from the blowpipe and mounted. Though it is desirable to have larvae arranged on their food plants, many will prefer to mount them on pins. Twist a light wire round a small cube of cork and bend as represented in the accompanying figure. The two free ends are brought together and gently inserted into the body cavity, their elasticity serving to hold the inflated larva in place, and a pin is thrust through the cube of cork. Some use a straw in place of the wire, pinning through the free end. Inflating and mounting on pins permits the placing of the specimens in cases beside the adults.

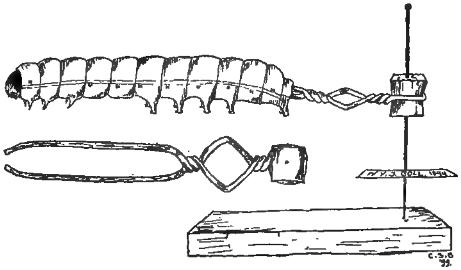
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FIG. 22 Inflated larva, showing method of mounting (original).

Alcoholic material. Many larvae and other soft forms can not be preserved by any of the preceding methods. They should be placed in small vials in 50% alcohol for a day or two, this replaced by 65% and that in turn by 75 to 85% alcohol. If attention is paid to changing the preservative fluid many larvae will keep well. White forms, as for example grubs and some caterpillars, change color less if they are dropped for a moment in boiling water before being placed in the alcohol.

Vials and their care. The vial should be no larger than necessary to hold the specimens and may have various shapes. Ordinary straight vials, preferably with no neck, should be stored in small racks in an upright position or the alcohol will escape more or less by capillary action. As it is desirable to have all the stages of an insect together, various plans have been devised for keeping alcoholic material in cases with the adults. For trays bent necked vials are much used. In the United States national museum the ordinary round vials with bent necks are slipped between curved wires fixed to a block, which is held firmly in the tray by forcing into the cork the two short brads in its under surface. This arrangement permits the storage of all forms together without much additional weight. In order to avoid distortion caused by the curved surface of an ordinary vial, Professor Comstock of Cornell university uses a square form made with a bent neck, but the extra expense and increased weight will tend to prevent its adoption to a great extent.

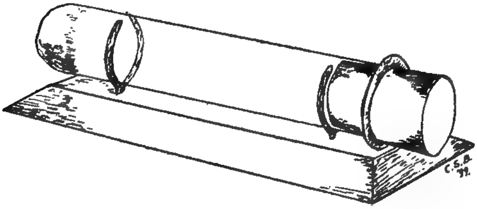

FIG. 23 Vial mounted on block (original).

Vials containing insects should be kept full of alcohol, as specimens so preserved are much less injured by jarring, and as they are always covered by the fluid, even when the vials are on their side, there is less opportunity for discoloration. Rubber stoppers are regarded as best, though first quality corks give good results. In order to have the vial full, plenty of alcohol is put in and a pin held against the upper side of the stopper as it is inserted, allows the air to escape and also the small amount of superfluous liquid.

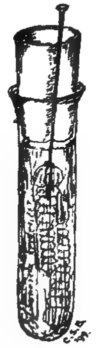

FIG. 24 Use of pin in corking vial (original).

Labeling insects. Now that considerable attention is being paid to the distribution and life history of insects, no specimen should be mounted without putting on the pin with it a label bearing at least the locality and date of its capture. This record should be intelligible to all. The name and abbreviation of both town and state should appear, for if only the town is given and the specimen sent to another state in exchange, serious confusion might result. For the same reason it is better to use an abbreviation for the month, rather than a numeral, because 5, 7/99 may mean either May 7/99 or 5 July '99, according to the custom of the reader. This label should be small, in order to economize space, and should always accompany the specimen. It costs little, is neater and

Albany, N. Y. June 1899 N. Y. S. Coll.	Albany, N. Y. June 1899 N. Y. S. Coll.	Albany, N. Y. June 1899 N. Y. S. Coll.	Albany, N. Y. June 1899 N. Y. S. Coll.	Albany, N. Y. June 1899 N. Y. S. Coll.

FIG. 25 Locality and date labels used in state etomologist's office.

saves space to have these labels printed, leaving blanks for the day of the month and the year. If these are set solid when printed, no trimming will be necessary as the labels have only to be cut apart. When writing labels, specially for alcoholic specimens, use india or an engrossing ink, as ordinary inks fade after a few years exposure to light. In the case of insects received from others it is well to include the name of the donor, which may either be on the same label with the locality and date or on a separate slip. When the name of the insect is known, that may be written on a larger label and put on the pin below the locality label. It is sometimes very desirable to attach other information to a specimen, but the capacity of a label is limited, and for this purpose numbers may be used. A numeral is given each insect with something worthy of note and the record entered opposite this number in a book or on a slip. In case it is desirable to make one record applying to a large number of specimens, specially if widely separated, a lot number may be given and a small label bearing it put on the pin of each. This lot number refers in a similar manner to a record book concerning the various lots of insects. For example one lot has been determined by a specialist, while another may have been taken under peculiar conditions.

Insect cases. A collector soon finds himself with a number of specimens and no place to store them. At first they may be put in cigar boxes, or even in pasteboard boxes, but museum pests find them readily in such places and rapid ruin follows unless the most vigilant care is exercised. The destructiveness of pests renders a tight case of some form a necessity. To exclude insects, light, dust and other enemies of a collection, various cases have been designed and are for sale by dealers. The essentials of a good case are that it shall be tight when closed, of a convenient size, durable and not too expensive. It must be well made or in the course of a few years warping and checking render it practically worthless. It will also be found economical to have the case lined with sheet or pressed cork to facilitate pinning specimens. The Schmidt case is very good and convenient in many respects and is extensively used in the United States national museum. It is made of white pine, shellacked or varnished, and has outside dimensions of 33x21.5x6.7 cm (13x8$\frac{1}{2}$x2$\frac{5}{8}$ in.). The top and bottom are cross grain veneered, the latter lined with cork, the two halves hinged at the back and held together tightly with hooks and eyes.

A good case, extensively used by Dr Lintner in his private collection, has outside dimensions of 29.2x36.7x6.1 cm (11$\frac{1}{2}$x14$\frac{1}{2}$x2$\frac{1}{2}$ in.) and inside a clear space of 4.2 cm (1$\frac{3}{4}$ in.). The sides are 1.2 cm ($\frac{7}{16}$ in.) thick, of well-seasoned pine or whitewood, and are lined with tea lead, the lining extending for a short distance over the corked bottom, which is composed of .8 cm ($\frac{5}{16}$ in.) stuff. The covering glass 27.7x35.5 cm ($10\frac{7}{8}$x$13\frac{7}{8}$ in.) fits into a rabbet .5x.8 cm ($\frac{3}{16}$x$\frac{5}{16}$ in.), and is held down closely on the tea lead with glazier's triangles. The cork lining the bottom is covered with white paper and the whole outside with manila paper. This case can be made by anyone having some skill with carpenter's tools, and if well constructed is very rarely troubled by pests, the lead apparently being obnoxious to them.

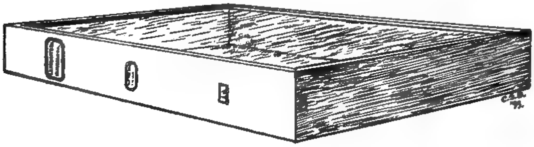

FIG. 26 Insect case much used by Dr Lintner (original).

For the display of butterflies and moths, a larger case, preferably a horizontal tray, is desirable. In adopting a large drawer it is well to select a size uniform with those used in museums and to insist on the trays being interchangeable. One of the best insect cases is the form adopted by the late Dr Riley for the United States national museum. It is 45.5 cm (18 in.) square and has an outside depth of 7.6 cm (3 in.). The sides and back are .9 mm ($\frac{3}{8}$ in.) and the front of 1.6 cm ($\frac{5}{8}$ in.) stuff, while the bottom is composed of three ply cross-grained veneer in order to prevent checking. The back and side pieces are dovetailed and the bottom fitted into a groove. Inside of the outer frame is a secondary box of 3 mm ($\frac{1}{8}$ in.) whitewood, closely fitted and held 6 mm ($\frac{1}{4}$ in.) from back and sides and 9 mm ($\frac{3}{8}$ in.) from the front by blocks. The space between the two boxes is used for insecticides, usually naphthaline, and the 6 mm ($\frac{1}{4}$ in.) tongue of the cover, a frame 1.9 cm ($\frac{3}{4}$ in.) wide and 9 mm ($\frac{3}{8}$ in.) thick holding a single thick glass, fits tightly into the space between the outer and inner box. The first lot was made of California redwood with a cover frame of mahogany, but those made later are of cheaper materials; basswood or whitewood is good. These trays are made to slide on a groove. The outside of the case may be left its natural color, but the inside should be lined with white paper or painted with zinc white. Professor Comstock recommends a paint formed by dissolving one part by weight of glue in five of water, thickening to the consistency of paint with zinc white, and applying while warm.

For the Cornell university collection, Professor Comstock has adopted a case with both top and bottom composed of glass. Its outside dimensions are 40.6x48.2x7.6 cm (16x19x3 in.) and the covers are both dovetailed and mitered. The top and bottom of the case are alike, except that the former is not quite so deep and is grooved to fit over the tongue of the latter. The bottom is covered with a series of wooden blocks 8 mm ($\frac{1}{3}$ in.) thick. 12 of his unit blocks just fill a box. There are various sizes adapted to different needs, the idea being to put all of one species on a single block, thus avoiding the necessity of repinning specimens in rearranging a case, as the blocks themselves can be moved. Where this system is used, it is found advantageous to have some of the larger blocks covered with cork.

Museum pests. In spite of great care and apparently tight cases, the enemies of an insect collection are liable to work into the boxes. As a deterrent to the entrance of insect pests, many entomologists use naphthaline in some form. Naphthaline cones mounted on pins are most convenient, but are rather costly as they retail by dealers at 75 cents a hundred, specially when naphthaline balls can be obtained for less then 10 cents a hundred. These latter can be mounted by thrusting with the aid of pliers the heated head of a pin into the ball. After it has cooled the ball will be firmly attached to the pin, which may then be stuck into the cork lining of any case.

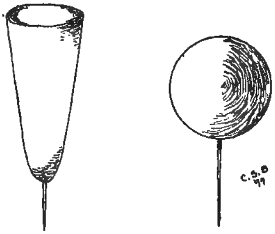

FIG.. 27 Naphthaline cone and ball (original).

The presence of museum pests is revealed by the particles of comminuted matter under the injured specimen. Infested cases should be treated with carbon bisulfid, pouring in about a teaspoonful, closing the case and allowing it to remain from several hours to a day. This substance evaporates readily and does not injure the specimens. As its gas is inflammable and explosive great care should be exercised to prevent its vapor coming in contact with any source of fire, as a lamp, lighted cigar, etc.

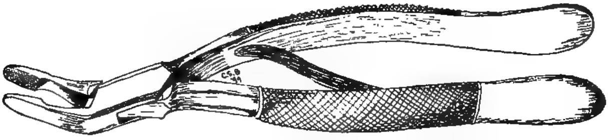

FIG. 28 Pinning forceps (original).

Convenient accessories. When arranging insects in a case, a pair of pinning forceps will be found a great convenience. The large nickel plated dental forceps are the best, but are too expensive for many.

Some cheaper forms are sold, or a pair of ordinary pliers may be used, specially if beveled on one side by grinding. One or more small blocks covered with cork will be found exceedingly convenient for the temporary reception of pinned specimens. A small pocket lens or magnifier is another valuable aid, even in the hands of the amateur, because when collecting in the field or arranging specimens, there is always some form or structure worthy of examination, and if attention is paid to any of the smaller insects a lens is a necessity. Very good pocket magnifiers may be bought at from $.65 to $5. One of the cheaper folding forms with two lenses will be of great service, and is in most cases the best for a beginner. Later a Coddington lens or an achromatic triplet may be purchased and employed for the more detailed examinations, but the cheap lens will also be used to a great extent.

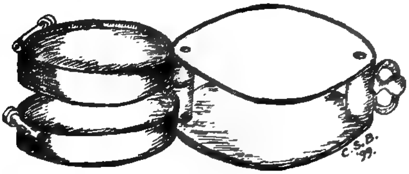

FIG. 29 Pocket lens (original).

Shipping insects. Though many insects are fragile they may be sent through the mails or by express without serious injury, by taking a few necessary precautions. Be sure the package is done up strongly. Lots of insects are received frequently in a dilapidated condition because a poor box was used. Pack insects only in very stout pasteboard boxes, or in light wooden or tin boxes. If pinned specimens are to be sent, they should be put in a small box, the pins firmly set with forceps and the box placed in a larger one, the space between the two being packed firmly with some elastic material. This latter is to lessen the jar and is effective only when not packed so tightly as to destroy its elasticity, and to be of service must be on all sides of the smaller box. Unmounted dead material can be sent safely done up in cotton batting and thin paper. First lay a little batting in the bottom and along the sides of the box, then a sheet of soft paper and put on it, separated slightly from each other, a number of insects, preferably those about the same size, cover with the same paper, lay in more cotton batting and thus fill the the box, taking care to put enough batting on top so that a slight pressure will be necessary to close the box. This will prevent the insects from shaking about and injuring each other.

Living caterpillars or other soft forms should be sent through the mails with a little of their food plant whenever practicable. There is no necessity of providing breathing holes, on the contrary larvae stand the journey better in a tight box which will not permit drying of the food plant. For this purpose a strong tin box is the best. If more than one species is to be sent, it is well to divide the box and separate them because some caterpillars are so pugnacious that they will destroy others and a few even those of their own kind. Some aquatic larvae will bear transportation very well if packed in damp sphagnum moss, though some of the more delicate forms would have to be put in vials containing 50% alcohol. When sending packages containing liquids through the mails, the government regulations should be observed. Insects are classed as merchandise and sent at the rate of one cent an ounce. The sender's name and address should appear on the upper left hand corner of the package in order to facilitate its identification.

Dealers in entomologic supplies. For the convenience of the novice the addresses of a few dealers are given.

A. Smith & Sons, 269 Pearl st. New York, N. Y.
John Akhurst, 78 Ashland place. Brooklyn, N. Y.
M. Abbott Frazar, 93 Sudbury st. Boston, Mass.
Entomological society of Ontario, 429 Wellington st. London, Ont.

DISTRIBUTION OF INSECTS

The continued introduction of insect pests from other countries and their spread and destructiveness in this land have resulted in considerable attention being given to this important subject. While it is undoubtedly true that many insects can not be excluded from the United States, the rigid inspection at ports of entry by California agents has resulted in the stoppage and destruction of many species before they could threaten any industry by extensive ravages.

Importance. The importance of knowing the actual distribution of injurious insects has hardly occurred to many. Isothermal lines have been indicated over this country and present some interesting curves, but the temperature does not entirely control though it undoubtedly greatly influences the distribution of insects. Degrees of moisture, variations in soil and other features also have their effect. In determining the physical limitations of one species, we gain some idea of those governing others. New York state possesses a most important port of entry, many ships unlading at New York city varied cargoes from all parts of the world. The long and low-lying Hudson river valley offers a natural pathway from this port into the state for such species as find our climate congenial. A number of important insect pests have already established themselves in this valley and are spreading over the state. As the climatic conditions limiting their existence in destructive numbers are not definitely known, it is proposed to give some attention to this important subject, at least in an incidental way, and ascertain the actual boundaries not only of the occurrence of an insect, but at what point it ceases to be a destructive pest and also any variations in the number of generations produced in different sections of the state. After several years of study of these subjects, general laws may be deduced that will be of considerable value in determining where such imported pests as the elm-leaf beetle, elm-bark louse, leopard moth, San José scale and others will be destructive. This knowledge will not only enable us to state whether an insect will be injurious in certain localities, but it may also give valuable aid in our attempts to prevent the introduction of insect pests and their subsequent spread over the state.

Life zones. A most valuable addition to our knowledge of factors governing the distribution not only of animals but also of plants, has been made by Dr Merriam and his associates in the United States department of agriculture. As a result the boundaries of certain life zones have been indicated with a considerable degree of accuracy. In New York state three life zones occur, the upper austral, the transition and the boreal. The upper austral includes the western end of Long Island, Staten Island, the Hudson river valley to near Mechanicville and an area bordering Lake Ontario and including Lakes Oneida, Cayuga, Seneca and some of the smaller bodies of water. The boreal is represented by a small area in the Catskills, a much larger one in the heart of the Adirondacks, a small one near the foot of Lake Ontario, and another of about equal size in the southwestern corner of the state. The presence of three life zones within our borders affords excellent facilities for studying the effect of climate upon insect life. It is believed that some attention to this line of work will prove not only of great scientific interest, but will also have an important practical bearing. Dr Howard is of the opinion that the imported elm-leaf beetle, the two asparagus beetles and the San José scale will be confined to the austral life zones. So far as known at present, they are thus limited in this state, though the common asparagus beetle has been taken by my assistant, Mr Banks, near Fort Ticonderoga. This means either that the asparagus beetle can exist on the border of the transition life zone or else that the upper austral extends farther up the Hudson river than at first supposed. The following are some of the native insects which Dr Howard places as austral species, that is confined to the lower and upper austral life zones: Cicada killer, *Megastizus speciosus* Drury, bag worm, *Thyridopteryx ephemeraeformis* Haw, saddle back caterpillar, *Sibine stimulea* Clem., nine pronged wheel bug, *Prionidus cristatus* Linn., harlequin cabbage bug, *Murgantia histrionica* Hahn, tulip scale, *Lecanium tulipiferae* Cook, and Carolina mantis, *Stagmomantis carolina* Linn. Exact records of the occurrence of these forms are rare, and notes in regard to them and their relative abundance will be welcomed.

Imported insect pests. The formidable list of injurious insects which have invaded the United States from other countries and now cause immense annual losses, illustrate the importance of this subject. Without attempting an exhaustive compilation, the following are some of the more destructive insects. Attacking the apple, pear, cherry and peach; codling moth, *Tmetocera ocellana* Schiff., apple aphis, *Aphis mali* Fabr., apple tree bark louse, *Mytilaspis pomorum* Bouché, San José scale, *Aspidiotus perniciosus* Comst., pear midge, *Diplosis pyrivora* Riley, bark borer, *Xyleborus dispar* Fabr., pear psylla, *Psylla pyricola* Foerst, cherry aphis, *Myzus cerasi* Fabr., and the peach bark borer, *Scolytus rugulosus* Ratz. These species are well known as dangerous enemies of fruit trees.

Gypsy moth, *Porthetria dispar* Linn., elm-leaf beetle, *Galerucella luteola* Müll., and elm-bark louse, *Gossyparia ulmi* Geoff., are three bad enemies of elms. The first named does not occur in this state, though it has committed extensive ravages in eastern Massachusetts. Wheat has suffered most severely from the Hessian fly, *Cecidomyia destructor* Say, the grain aphis, *Nectarophora granaria* Kirby and from the wheat midge, *Diplosis tritici* Kirby, while clover is frequently attacked by the clover leaf weevil, *Phytonomus punctatus* Fabr., or after it has been dried, by the clover hay worm, *Pyralis costalis* Fabr. A few other imported pests may be named; asparagus beetles *Crioceris asparagi* Linn., and *C. 12-punctata* Linn., onion fly, *Phorbia ceparum* Meigen, cow horn fly *Haematobia serrata* Rob.-Desv., carpet beetle, *Anthrenus scrophulariae* Linn., larder beetle, *Dermestes lardarius* Linn., red ant, *Monomorium pharaonis* Linn. and the croton bug, *Phyllodromia germanica* Fabr.

There is hardly a person who can not recognize in the above-named insects, one or more which has caused him considerable loss, while the farmer knows many of them from sad experience. Yet these have all been introduced from abroad and some are still spreading over the country. Of the 73 injurious species regarded by Dr Howard as of first mportance, each causing annual losses running into hundreds of thousands of dollars, 37 have been introduced, 30 are known to be native, while the original home of 6 is open to question. An effort is being made by the state of Massachusetts to exterminate the gypsy moth. If the fight is given up, another pest will make its way over the land and exact a heavy tribute. It would certainly cost Massachusetts people very much less than $200,000 annually, about what is appropriated at present, to maintain a very efficient system of inspection and treatment to prevent the introduction of insect pests. It is impossible to say beforehand just what insects may become acclimated and injurious, but were due attention given this subject, the danger of admitting such pests could be reduced to a minimum.

Manner of spread. Scale insects as is well known to many from bitter experience are readily spread by transportation of nursery stock, but not of fruit. The young are frequently carried by birds for short distances, and it has been demonstrated that winds will do the same. The English sparrow seems to be an active agent in spreading certain scale insects, for the elm-bark louse, *Gossyparia ulmi* Geoff., probably owes its general distribution over Albany and Troy to this bird. Some species like the gypsy moth which has well-developed wings but does not use them to any extent, and the white-marked tussock moth, the female of which is wingless, depend very largely upon the caterpillars crawling or being carried by some agency. The young larvae may be blown some distance by winds, but many are carried by animals, teams and other conveyances. Elm-leaf beetles are frequently seen resting on the clothing of people and there is no reason why they should not be carried by teams. In Troy, N. Y., it seems as if the electric cars were prominent factors in distributing this pest over the city. Many insects are transported in soil or rubbish accompanying their food plant. Such is probably the case with both asparagus beetles, for otherwise their occurrence here and there in the state could hardly be explained. Many winged insects fly long distances, and when this is true of the females, there is little hope of restricting their spread. The presence of well-developed wings is no proof that the insect flies great distances, though some are known to take extended flights. The monarch butterfly, *Anosia plexippus* Linn., is believed unable to stand our northern winters and the race is maintained here only by adults flying from the south. There are a number of records of butterflies being found at sea, in one instance 1000 miles from the mainland. Certain owlet moths, or Noctuidae, and the hawk moths, Sphingidae, have a strong flight and some species have been found far out at sea. Honey and bumble bees fly considerable distances and the same is true of certain beetles. In early spring it is by no means uncommon to see Colorado potato beetles flying over fields of considerable extent in search of their food plant, yet this insect required about 15 years to make its way from Colorado to New England.

Practical application. In the case of canker worms, the white-marked tussock moth and other species with wingless females, advantage can be taken of their limited means of distribution to exclude them from trees once cleaned. This possibility warrants considerable expense in clearing them from a tree. The introduction of scale or other insects on a farm may be prevented to a great extent by studying their means of distribution and adopting proper methods to attain the desired results. It would be much safer to buy trees that have been fumigated, or even undergo the expense of fumigating purchased stock, rather than admit a pest that can be excluded by reasonable care. There are some insects which fly relatively short distances, for example the elm-leaf beetle; the parent of the apple maggot is said to have this habit, and there are probably others, but we know altogether too little regarding how far each species will fly. Those confined to relatively short aerial flights can be kept in check in one orchard with comparative ease, even though neighboring ones are badly affected, but such is not the case when the females habitually fly long distances before depositing eggs. It is only under exceptional circumstances that the length of flight can be determined for a species, but whenever an opportunity offers it should be seized. Studying the spread of insects is most fascinating field work, something that may be taken up by all and is also of great practical value, because an insect can not be controlled in the best way till its limitations in this respect are known.

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COMPILED UNDER THE DIRECTION OF THE ENTOMOLOGIST, FOR THE
USE OF STUDENTS AND OTHER WORKERS, AS WELL AS FOR
THOSE ABOUT TO BEGIN THE COLLECTING
AND STUDY OF INSECTS.

BY

NATHAN BANKS,
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 5, 1900.

SIR: I have the honor to transmit herewith the manuscript of a bulletin for which there has been much demand among workers in entomology, and the publication of which I recommend under the title, Bulletin No. 24, new series, "A List of Works on North American Entomology."

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

INTRODUCTORY NOTE.

In 1888 there was published under the Division of Entomology, as Bulletin No. 19, "An enumeration of the published synopses, catalogues, and lists of North American insects," etc. This bulletin has served a very useful purpose in enabling a full answer to inquiries regarding the works most useful in the determination of our native insects and also regarding the most useful general works of reference. Since the publication of Bulletin No. 19, however, there has been very great activity in entomological work, and the bulletin is now well behind the times. Anyone who has ever taken up the study of entomology realizes the difficulty of securing a comprehensive review of the literature, even of a small group, while to secure publications which will enable him to determine the known species in most of the groups is more or less difficult. In fact, it is difficult to learn even the title of such papers and where to procure them. This latter difficulty will be solved by the present bulletin. Mr. Banks has not compiled a complete bibliography of the literature of North American insects, but has given briefly the references to such works and papers as are most useful for the identification of our insects. The old list has been added to greatly, and in fact the number of papers cited is almost double that of the previous bulletin.

L. O. H.

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A LIST OF WORKS ON NORTH AMERICAN ENTOMOLOGY.

COMPREHENSIVE WORKS MOST USEFUL FOR THE STUDY OF NORTH AMERICAN INSECTS.

THOMAS SAY.—Complete writings on the entomology of North America; edited by J. L. LeConte. New York, 1859.

Principally descriptions of new species; contains a glossary to entomological terms. Now out of print.

J. H. COMSTOCK.—A manual for the study of insects. Ithaca, Comstock Publishing Company, 1895. Price, $4.50.

Almost indispensable to the student.

A. S. PACKARD.—Guide to the study of insects. New York, Henry Holt & Co. Price, $5. Many editions. (First edition, Salem, 1869.)

A. S. PACKARD.—A text-book of entomology. New York, The Macmillan Company, 1898. Price, $4.50.

Especially valuable for anatomy and morphology.

ALPHEUS HYATT and J. M. ARMS.—Insecta. No. VIII, Guides for science teaching. Boston, D. C. Heath & Co., 1890. Price, $1.25.

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H. C. C. BURMEISTER.—Handbuch der Entomologie. Berlin, 1832–1855. 5 vols. Vol. I. Allgemeine Entomologie.

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BULLETIN No. 1.—Reports of Experiments, chiefly with Kerosene, upon the Insects injuriously affecting the Orange Tree and the Cotton Plant, made under the Direction of the Entomologist. (1883.) [pp. 62.]

BULLETIN No. 2.—Reports of Observations on the Rocky Mountain Locust and Chinch Bug, together with Extracts from the Correspondence of the Division on Miscellaneous Insects. (1883.) [pp. 36.]

BULLETIN No. 3.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. With plates. (1883.) [pp. 75, pls. 3.]

BULLETIN No. 4.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist, together with Extracts from Correspondence on Miscellaneous Insects. (1884.) [pp. 102, figs. 4.]

BULLETIN No. 5.—Descriptions of North American Chalcididæ from the Collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological Notes. [First paper.] Together with a List of the described North American Species of the Family. By L. O. Howard, M. Sc., Assistant, Bureau of Entomology. (1885.) [pp. 47.]

BULLETIN No. 6.—The imported Elm-leaf Beetle. Its Habits and Natural History, and Means of counteracting its Injuries. (1885.) [pp. 18, fig. 1, pl. 1.]

Bulletin No. 7.—The Pediculi and Mallophaga affecting Man and the Lower Animals. By Herbert Osborn. (1890.) [pp. 56, figs. 42.]

Bulletin No. 8.—The Periodical Cicada. An Account of *Cicada septendecim* and its tredecim Race, with a Chronology of all of the broods known. By Charles V. Riley, Ph. D. (1885.) [pp. 46, figs. 8.]

Bulletin No. 9.—The Mulberry Silk-worm; being a Manual of Instructions in Silk Culture. By Charles V. Riley, M. A., Ph. D. (1886.) [pp. 65, figs. 29, plates 2.]

Bulletin No. 10.—Our Shade Trees and their Insect Defoliators. Being a Consideration of the four most injurious Species which affect the Trees of the Capital; with Means of destroying them. By Charles V. Riley, Entomologist. (1887.) [pp. 75, figs. 27.]

Bulletin No. 11.—Reports of Experiments with various Insecticide Substances, chiefly upon insects affecting garden crops, made under the Direction of the Entomologist. (1886.) [pp. 34.]

Bulletin No. 12.—Miscellaneous Notes on the work of the Division of Entomology for the Season of 1885; prepared by the Entomologist. (1886.) [pp. 45, pl. 1.]

Bulletin No. 13.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (With illustrations.) (1887.) [pp. 78, figs. 4.]

Bulletin No. 14.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1887.) [pp. 62, figs. 2, pl. 1.]

Bulletin No. 15.—The Icerya, or Fluted Scale, otherwise known as the Cottony Cushion Scale. (Reprint of some recent Articles by the Entomologist and of a Report from the Agricultural Experiment Station, University of California.) (1887.) [pp. 40.]

Bulletin No. 16.—The Entomological Writings of Dr. Alpheus Spring Packard. By Samuel Henshaw. (1887.) [pp. 49.]

Bulletin No. 17.—The Chinch Bug. A general Summary of its History, Habits, Enemies, and of the Remedies and Preventives to be used against it. By L. O. Howard, M. S., Assistant Entomologist. (1888.) [pp. 48, figs. 10.]

Bulletin No. 18.—The Life and Entomological Work of the late Townend Glover. By C. R. Dodge. (1888.) [pp. 68.]

Bulletin No. 19.—An Enumeration of the Published Synopses, Catalogues, and Lists of North American Insects. By. E. A. Schwarz. (1888.) [pp. 77.]

Bulletin No. 20.—The Root-knot Disease of the Peach, Orange, and other plants in Florida, due to the work of Anguillula. By J. C. Neal. (1889.) [pp. 31, pls. 21.]

Bulletin No. 21.—Report of a Trip to Australia, made under the Direction of the Entomologist, to Investigate the Natural Enemies of the Fluted Scale. By Albert Koebele. (1890.) [pp. 32.]

Bulletin No. 22.—Reports of Observations and Experiments in the Practical Work of the Division. (1890.) [pp. 110.]

Bulletin No. 23.—Reports of Observations and Experiments in the Practical Work of the Division. (1891.) [pp. 83.]

Bulletin No. 24.—The Boll Worm of Cotton. A report of progress in a supplementary investigation of this insect. By F. W. Mally. (1891.) [pp. 50.]

Bulletin No. 25.—Destructive Locusts. A popular consideration of a few of the more injurious locusts (or "grasshoppers") of the United States, together with the best means of destroying them. By C. V. Riley. (1891.) [pp. 62, plates 12.]

Bulletin No. 26.—Reports of Observations and Experiments in the Practical Work of the Division. (1892.) [pp. 95.]

Bulletin No. 27.—Reports on the Damage by Destructive Locusts during the Season of 1891. (1892.) [pp. 64.]

Bulletin No. 28.—The More Destructive Locusts of America, North of Mexico. By Lawrence Bruner. (1893.) [pp. 40.]

Bulletin No. 29.—Report on the Boll Worm of Cotton. By F. W. Mally. (1893.) [pp. 73.]

Bulletin No. 30.—Reports of Observations and Experiments in the Practical Work of the Division. (1893.) [pp. 67.]

Bulletin No. 31.—Catalogue of the Exhibit of Economic Entomology at the World's Columbian Exposition. (1893.) [pp. 121.]

Bulletin No. 32.—Reports of Observations and Experiments in the Practical Work of the Division. (1894.) [pp. 59.]

Bulletin No. 33.—Legislation against Injurious Insects; a compilation of the laws and regulations in the United States and British Columbia. By L. O. Howard. (1893.) [pp. 46.]

Bulletin No. 1, new series.—The Honey Bee: A manual of instruction in Apiculture. By Frank Benton. (1896.) [pp. 118, pls. 11.]

Bulletin No. 2, new series.—Proceedings of the Seventh Annual Meeting of the Association of Economic Entomologists. (1895.) [pp. 100.]

Bulletin No. 3, new series.—The San Jose Scale: Its occurrence in the United States with a full account of its life history and the remedies to be used against it. By L. O. Howard and C. L. Marlatt. (1896.) [pp. 80, plate 1.]

BULLETIN No. 4, NEW SERIES.—The principal Household Insects of the United States. By L. O. Howard and C. L. Marlatt. With a Chapter on Insects affecting dry Vegetable Foods. By F. H. Chittenden. (1896.) [pp. 130.]

BULLETIN No. 5, NEW SERIES.—Insects affecting Domestic Animals: An account of the species of importance in North America, with mention of related forms occurring on other animals. By Herbert Osborn. (1896.) [pp. 302, pls. 5.]

BULLETIN No. 6, NEW SERIES.—Proceedings of the Eighth Annual Meeting of the Association of Economic Entomologists. (1896.) [pp. 100.]

BULLETIN No. 7, NEW SERIES.—Some Miscellaneous Results of the Work of the Division of Entomology. (1897.) [pp. 87.]

BULLETIN No. 8, NEW SERIES.—Some little-known Insects affecting Stored Vegetable Products: A collection of articles detailing certain original observations made upon insects of this class. By F. H. Chittenden. (1897.) [pp. 45.]

BULLETIN No. 9, NEW SERIES.—Proceedings of the Ninth Annual Meeting of the Association of Economic Entomologists. (1897.) [pp. 87.]

BULLETIN No. 10, NEW SERIES.—Some Miscellaneous Results of the Work of the Division of Entomology. (1898.) [pp. 99.]

BULLETIN No. 11, NEW SERIES.—The Gipsy Moth in America: A summary account of the introduction and spread of *Porthetria dispar* in Massachusetts and of the efforts made by the State to repress and exterminate it. By L. O. Howard. (1897.) [pp. 39.]

BULLETIN No. 12, NEW SERIES.—The San Jose Scale in 1896–97. By L. O. Howard. (1898.) [pp. 31.]

BULLETIN No. 13, NEW SERIES.—Recent Laws against Injurious Insects in North America, together with the Laws relating to Foul Brood. By L. O. Howard. (1898.) [pp. 68.]

BULLETIN No. 14, NEW SERIES.—The Periodical Cicada: An account of *Cicada septendecim*, its natural enemies, and the means of preventing its injury, together with a summary of the distribution of the different broods. By C. L. Marlatt. (1898.) [pp. 148, pl. 1.]

BULLETIN No. 15, NEW SERIES.—The Chinch Bug: Its probable origin and diffusion, its habits and development, natural checks and remedial and preventive measures, with mention of the habits of an allied European species. By F. M. Webster. (1898.) [pp. 82.]

BULLETIN No. 16, NEW SERIES.—The Hessian Fly in the United States. By Herbert Osborn. (1898.) [pp. 57, pls. 2.]

BULLETIN No. 17, NEW SERIES.—Proceedings of the Tenth Annual Meeting of the Association of Economic Entomologists. (1898.) [pp. 104.]

BULLETIN No. 18, NEW SERIES.—Some Miscellaneous Results of the Work of the Division of Entomology. III. (1898.) [pp. 101.]

BULLETIN No. 19, NEW SERIES.—Some Insects Injurious to Garden and Orchard Crops. A series of articles dealing with insects of this class. By F. H. Chittenden. (1899.) [pp. 99.]

BULLETIN No. 20, NEW SERIES.—Proceedings of the Eleventh Annual Meeting of the Association of Economic Entomologists. (1899.) [pp. 111.]

BULLETIN No. 21, NEW SERIES.—Preliminary Report on the Insect Enemies of Forests in the Northwest. By A. D. Hopkins. (1899.) [pp. 27.]

BULLETIN No. 22, NEW SERIES.—Some Miscellaneous Results of the Work of the Division of Entomology. IV. (1900.) [pp. 109.]

BULLETIN No. 23, NEW SERIES.—Some Insects Injurious to Garden Crops. By F. H. Chittenden. (1900.) [pp. 92.]

INSECTS AFFECTING THE ORANGE.—Report on the Insects Affecting the Culture of the Orange and other Plants of the Citrus Family, with Practical Suggestions for their Control or Extermination. By H. G. Hubbard. (1885.) [pp. x+227, figs. 95, pls. 14.]

INSECT LIFE.—Seven volumes. Begun in July, 1888, ended July, 1895. General index to the seven volumes of Insect Life, pp. 145, 1897.

REPORT ON COTTON INSECTS.—By J. Henry Comstock. (1879.) [pp. 511, figs. 77, pls. 3.]

SPECIAL REPORT No. 11.—The Silkworm; being a brief Manual of Instructions for the Production of Silk. Prepared, by direction of the Commissioner of Agriculture, by C. V. Riley, M. A., Ph.D., Entomologist. (First ed., 1879; fifth ed., 1885.) [pp. 37, figs. 8.]

SPECIAL REPORT No. 35.—Report on Insects injurious to Sugar Cane. Prepared, under direction of the Commissioner of Agriculture, by J. Henry Comstock, Entomologist. (1881.) [pp. 11, figs. 3.]

[NOTE.—During the years 1864 to 1876, inclusive, the Department of Agriculture published regularly monthly reports, mainly statistical in their character (replaced since 1876 by the series of monthly "Crop Reports"), but which contained many short articles by the Entomologist, none of which would come within the scope of the present bulletin. Reference to these articles may be facilitated by consulting the "Synoptical Index of the Reports of the Statistician, 1863–1894" (Bul. No. 2, Division of Publications, Department of Agriculture). In like manner the "Index to the Annual Reports of the Department of Agriculture, 1837–1893" (Bul. No. 1 of the same series), may be used to facilitate reference to the entomological reports, articles, and notes appearing in the Annual Reports of the Department.

THE MORE IMPORTANT PERIODICALS CITED IN THIS BULLETIN.

AMERICAN PERIODICALS.

THE AMERICAN NATURALIST. A monthly journal devoted to the natural sciences in their widest sense. Thrity-three volumes published up to 1900.

ANNALS OF THE LYCEUM OF NATURAL HISTORY OF NEW YORK. Eight volumes. 1824–1867.

ANNALS OF THE NEW YORK ACADEMY OF SCIENCE. New York, N. Y. Thirteen volumes.

BULLETIN OF THE AMERICAN MUSEUM OF NATURAL HISTORY. New York, N. Y. Ten volumes published.

BULLETIN OF THE BROOKLYN ENTOMOLOGICAL SOCIETY. Seven volumes. 1878–1885.

BULLETIN OF THE BUFFALO SOCIETY OF NATURAL HISTORY. Five volumes completed, beginning with 1874.

BULLETIN OF THE ILLINOIS STATE LABORATORY OF NATURAL HISTORY. Urbana, Ill. Five volumes published.

BULLETINS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES, F. V. Hayden in charge. Department of the Interior; beginning with 1875.

BULLETINS OF THE UNITED STATES NATIONAL MUSEUM. Department of the Interior; beginning with 1875.

THE CANADIAN ENTOMOLOGIST. Edited by William Saunders and lately by C. J. S. Bethune; thirty-one volumes published up to the end of 1900. Published at London, Ontario.

ENTOMOLOGICA AMERICANA. Published by the Brooklyn Entomological Society, at Brooklyn, N. Y. Seven volumes.

ENTOMOLOGICAL NEWS, and proceedings of the entomological section of the Academy of Natural Sciences. Philadelphia, Pa. Commenced in 1890.

THE ENTOMOLOGICAL STUDENT. Philadelphia. Begun in April, 1900.

JOURNAL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA. Commencing with 1817.

JOURNAL OF THE NEW YORK ENTOMOLOGICAL SOCIETY. Commenced in 1893.

THE KANSAS UNIVERSITY QUARTERLY. Lawrence, Kans. Eight volumes published.

MEMOIRS OF THE BOSTON SOCIETY OF NATURAL HISTORY. Commencing with 1866.

OCCASIONAL MEMOIRS OF THE CHICAGO ENTOMOLOGICAL SOCIETY. Commenced in 1900.

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA. Beginning with 1841.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA. Commencing with 1860.

PROCEEDINGS OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES. Boston, Mass. Thirty-five volumes published.

PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY. Commencing with 1841.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES. San Francisco, Cal. Since 1854.

PROCEEDINGS OF THE DAVENPORT ACADEMY OF NATURAL SCIENCES. Davenport, Iowa. Six volumes published.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA. Six volumes. 1861–1867.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON. Four volumes published.

PROCEEDINGS OF THE IOWA ACADEMY OF SCIENCES. Des Moines, Iowa. Six volumes published.

PROCEEDINGS OF THE KANSAS ACADEMY OF SCIENCES. Topeka, Kans. Sixteen volumes published.

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM. Department of the Interior. Beginning with 1878.

PAPILIO. Devoted exclusively to Lepidoptera. Organ of the New York Entomological Club. Four volumes. 1881–1884.

PSYCHE. Organ of the Cambridge Entomological Club. Eight volumes issued up to date. Published at Cambridge, Mass.

REPORTS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES. Department of the Interior. Beginning with 1867.

SMITHSONIAN MISCELLANEOUS COLLECTIONS. Smithsonian Institution, Washington, D. C. Beginning with 1862.

TRANSACTIONS OF THE ACADEMY OF SCIENCE OF SAINT LOUIS. Ten volumes published.

TRANSACTIONS OF THE AMERICAN ENTOMOLOGICAL SOCIETY and proceedings of the Entomological Section of the Academy of Natural Sciences. Beginning with 1868, 26 volumes published up to 1900. Published at Philadelphia.

TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA. Second series beginning with 1818.

FOREIGN PERIODICALS.

ANNALES DE LA SOCIÉTÉ ENTOMOLOGIQUE DE BELGIQUE. Beginning with 1860. Published at Brussels.

ANNALES DE LA SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE. Beginning with 1832. Published at Paris.

BERLINER ENTOMOLOGISCHE ZEITSCHRIFT. Commencing with 1857.

DEUTSCHE ENTOMOLOGISCHE ZEITSCHRIFT. Herausgegeben von Dr. G. Kraatz. Berlin. Beginning with 1881.

ENTOMOLOGISCHE ZEITUNG. Herausgegeben von dem entomologischen Verein zu Stettin. Beginning with 1840.

LINNÆA ENTOMOLOGICA. Herausgegeben vom entomologischen Verein zu Stettin. Sixteen volumes. Berlin, 1846–1866.

ÖFVERSIGT AF KONGL. SVENSKA VETENSKAPS ACADEMIENS FÖRHANDLINGAR. Beginning with 1844. Published at Stockholm.
Proceedings of the Royal Swedish Academy of Sciences.

SITZUNGSBERICHTE DER MATHEMATISCH-NATURWISSENSCHAFTLICHEN CLASSE DER KAISERLICHEN ACADEMIE DER WISSENSCHAFTEN ZU WIEN. Beginning with 1848.

TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON. Beginning with 1791.

TRANSACTIONS OF THE LONDON ENTOMOLOGICAL SOCIETY. Beginning with 1836.

VERHANDLUNGEN DER ZOOLOGISCH-BOTANISCHEN GESELLSCHAFT IN WIEN. Beginning with 1852.

ZEITSCHRIFT FÜR DIE ENTOMOLOGIE. Herausgegeben von E. F. Germar. Five volumes. Leipzig, 1839–1844.

MITTHEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT. Bulletin de la Société entomologique suisse. Ten volumes published up to 1900. Published at Geneva.

ANNALS AND MAGAZINE OF NATURAL HISTORY. London. Beginning with 1838.

REVUE ET MAGASIN DE ZOOLOGIE PURE ET APPLIQUÉE. Paris. Beginning with 1839.

ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE. Leipzig. Beginning with 1848.

ARCHIV FÜR NATURGESCHICHTE. Berlin. Beginning with 1835.

ILLUSTRIERTE WOCHENSCHRIFT (now Zeitschrift) FÜR ENTOMOLOGIE. Neudamm, Germany. Commenced in 1896.

ENTOMOLOGISK TIDSKRIFT. Stockholm. Twenty volumes published.

REVUE D'ENTOMOLOGIE, PUBLIÉE PAR LA SOCIÉTÉ FRANÇAISE D'ENTOMOLOGIE. Caen, France. Eighteen volumes published.

Wiener entomologische Zeitung. Vienna. Eighteen volumes published.

The Entomologist's Record and Journal of Variation. London. Eleven volumes published.

Tijdschrift voor Entomologie. 's Gravenhage, Holland. Forty-two volumes published.

Bullettino della Societa Entomologica Italiana. Florence. Thirty-one volumes published.

Horæ Societatis Entomologicæ Rossicæ. St. Petersburg. Thirty-three volumes published.

Annales des Sciences Naturelles. Paris. Commencing with 1824.

HOW TO OBTAIN ENTOMOLOGICAL BOOKS AND PAMPHLETS.

Comparatively few of the works treating of the classification of North American insects have been published as separate books; but such as have been so published, if of comparatively recent date, can be obtained through the regular book trade. By far the greater number of the monographs and synopses mentioned in the preceding pages have been published in scientific periodicals and transactions of scientific societies. These periodicals and transactions can be obtained through the societies which publish them and through the publishers; but, in the case of transactions, single volumes, and more especially single papers, are seldom sold, and the older volumes are liable to be out of print. Moreover, the expense attending the purchase of all of the periodicals containing the publications on a given order of insects will be so great as to put them beyond the reach of most entomologists. The custom of placing at the disposal of authors a number of separate copies of their papers overcomes this difficulty to some extent and creates a small supply. Thus it often happens that a person interested can obtain a copy of a scientific paper by addressing the author personally. Many of these separate copies also get into the possession of dealers in second-hand books, and can be purchased from them. The American Entomological Society, Philadelphia, Pa., and also a few other societies here and in Europe offer for sale from their duplicates many of these authors' extras, and in some cases publish lists. There are, moreover, certain business establishments which make a specialty of the sale of works and pamphlets on natural history, including entomology, and it is chiefly through such establishments that the student is enabled to secure the larger portion of the works needed.

In Europe there are several of considerable reputation. All of those publishing catalogues of entomological books and pamphlets are included in the following list:

R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany.

Ed. André, 21, Boulevard Bretonnière, Beaune (Côte-d'Or), France.
H. W. Schmidt, Rannische Strasse, Nr. 1, Halle a. S, Germany.
J. B. Baillière et fils, 19, Rue Hautefeuille, Paris, France.
Oswald Weigel, Königsstrasse, 1, Leipzig, Germany.
U. Hoepli, Corso Vitt. Eman., 37, Milan, Italy.
Otto Harrassowitz, Querstrasse, 14, Leipzig, Germany.
William Wesley & Son, 28 Essex street, Strand, London, England.
Max Weg, Leplaystrasse, 1, Leipzig, Germany.
Paul Klincksieck, 52, Rue des Écoles, Paris, France.
K. F. Koehler's Antiquarium, Kurprinzstrasse, 6, Leipzig, Germany.
F. L. Dames, Voss-Strasse, 32, Berlin, Germany.
Dulau & Co., 37 Soho square, London, W., England.
A. Hermann, 8, Rue de la Sorbonne, Paris, France.
John Wheldon & Co., 58 Great Queen street, London, England.
Franz Pietzcker, Tübingen, Germany.
Ernst Heyne, Hospitalstrasse, 2, Leipzig, Germany.
Joseph Baer, Rossmarkt, 18, Frankfurt-am-Main, Germany.
List & Francke, Thalstrasse, Nr. 2, Leipzig, Germany.
W. Junk, Rathenowerstrasse, 22, Berlin NW. 5, Germany.

A not inconsiderable portion of the North American literature on the classification of insects has been published by the General Government through various channels, and foremost among them are the Smithsonian Institution, the U. S. Department of Agriculture, the U. S. National Museum, the U. S. Geological and Geographical Survey, and the reports of the various surveys of the Territories. Many of these publications are distributed free of cost to anyone applying for them; while others, like certain of the Smithsonian publications, are sold at a moderate price to cover the cost of publication. Many of them are out of print, and can only be obtained through natural history book dealers.

The State reports of Lintner and Forbes can be obtained from the secretaries of the respective State agricultural societies at Albany, N. Y., and Springfield, Ill., while the reports of the entomologists of the State experiment stations can be obtained from the directors of the respective stations. The older reports of the State entomologist of Missouri and the State entomologists of Illinois (Walsh, Le Baron, and Thomas) are all out of print and can only be obtained by purchase from secondhand dealers. The same may be said of the well-known and often quoted reports of Dr. Fitch, which were published with the old volumes of the Transactions of the New York State Agricultural Society.

O

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 19.

AN ENUMERATION
OF THE
PUBLISHED
SYNOPSES, CATALOGUES, AND LISTS
OF
NORTH AMERICAN INSECTS;

TOGETHER WITH OTHER INFORMATION INTENDED TO ASSIST THE STUDENT OF AMERICAN ENTOMOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., May 15, 1888.

SIR: I have the honor to submit for publication Bulletin No. 19 of this Division, being an enumeration of the published synopses, catalogues, and lists of North American insects; together with other information to assist the student of American Entomology.

Respectfully,

C. V. RILEY,
Entomologist.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture.

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SYNOPSES, CATALOGUES. AND LISTS OF NORTH AMERICAN INSECTS.

INTRODUCTION.

Inquiries regarding the works most useful for the determination of our native insects, as also about the most useful general works of reference, are among the most constantly recurring ones received by the Entomologist; but satisfactory and short replies are in most instances impossible, for the reason that the information is not contained in a few comprehensive works, but is scattered through many different periodicals and other publications. A complete list of such works, even of those pertaining to a single Order of insects, is too long to be given in an ordinary letter, and to obviate the difficulty experienced in such correspondence this bulletin has been prepared.

It was not our intention to compile a complete bibliography of the classification of North American insects, but to give briefly the references to such works and papers as are most useful for the identification of our insects. Thus, we originally planned to give only the titles of monographs or synopses of families or subfamilies and to reject all papers which contained disconnected descriptions of new species, or revisions and synopses of isolated genera. But while preparing the bulletin it was felt to be advisable to include smaller synoptic papers. For instance, several large families, *e. g.*, the Scarabæidæ among the Coleoptera, have recently been quite carefully revised, but the literature is in the form of synopses of single genera which, in their aggregate, form a more or less complete monograph of the whole family. In this case either these smaller synopses had to be mentioned in this bulletin or the whole family had to be omitted.

On the other hand, many of the monographs here mentioned are antiquated, so as to be of little value at the present time; or they are monographs comprising the genera and species of all countries, and difficult for the student of the American fauna to use, from the fact that the descriptions of the American genera are almost lost amongst the mass of foreign material.

It were futile to attempt to discriminate in such an enumeration between the more useful and the more or less useless, but as a rule we would recommend to the student to consult rather the later than the older publications. Unfortunately there are marked exceptions to the rule; as a few of the latest synoptic and descriptive papers by the younger authors are most insufficient and unsatisfactory. We have added a list of the special works on Economic Entomology, and also of those published by the U. S. Entomological Commission and by the Department.

There are a good many comprehensive classificatory works on European insects, but the almost complete absence of such works in this country is a great bar to the progress of entomology and is the inevitable outcome of the immense mass of material to be worked up and of the comparatively small number of workers in monographic entomology. As will be seen from the contents of this bulletin, the publications of this kind even in Orders most worked up, as in Coleoptera and Lepidoptera, are greatly scattered; while in the less popular Orders comparatively little has been done. Yet with the many earnest workers now in the field we may hope to see this present want met at no very remote period, and if the present bulletin should prove of temporary service it will not have been prepared in vain, though intended chiefly to relieve the Division of a great deal of letter-writing.

The preparation of the titles was originally placed in charge of Mr. B. Pickman Mann, but was in such shape when he left the office as to require almost entire rewriting. This has been mainly done by Mr. E. A. Schwarz, though other members of the Divisional force have assisted.

C. V. R.

PUBLISHED SYNOPSES, CATALOGUES, AND LISTS OF NORTH AMERICAN INSECTS.

COMPREHENSIVE WORKS MOST USEFUL FOR THE STUDY OF NORTH AMERICAN INSECTS.

H. C. C. BURMEISTER.—Handbuch der Entomologie. Berlin, 1832–'55. 5 vols. Vol. I. Allgemeine Entomologie.

The first volume treats of general entomology; Vol. II, part 1, of the Hemiptera; part 2, of Orthoptera; the remaining volumes of Coleoptera.

The first volume has been translated by W. E. Shuckard, under the title: Manual of Entomology. 1 vol. London, 1836.

J. O. WESTWOOD.—An introduction to the modern classification of insects, founded on the natural habits and corresponding organization of the different families. 2 vols. London, 1839–'40.

THOMAS SAY.—Complete writings on the Entomology of North America; edited by John L. Le Conte. New York, 1859.

H. A. HAGEN.—Bibliotheca Entomologica. Die Litteratur über das ganze Gebiet der Entomologie bis zum Jahre 1862. Leipzig, 1862.

A. S. PACKARD.—Guide to the study of insects. Henry Holt & Co., Philadelphia and New York. Many editions. (First edition, Salem, 1869.)

THE STANDARD NATURAL HISTORY. Edited by John Sterling Kingsley. Boston, S. E. Cassino & Co., 1884–'85.

Volume II contains the insects, which are treated by the following authors: *Hymenoptera*, J. H. Comstock and L. O. Howard; *Coleoptera*, Geo. Dimmock; *Lepidoptera*, H'y Edwards and C. H. Fernald; *Diptera*, S. W. Williston; *Orthoptera*, C. V. Riley; *Hemiptera*, P. R. Uhler; *Neuroptera*, A. S. Packard; *Arachnida*, J. H. Emerton.

HYMENOPTERA.

I.—CATALOGUES.

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George H. Horn.—On the genera of Carabidæ, with special reference to the fauna of Boreal America. <Trans. Amer. Entom. Soc., Vol. IX, 1882, pp. 91–196, Pl. III–X.

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CHAS. W. LENG.—Synopsis of Coleoptera [Cerambycidæ]. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, No. 1, p. 7, and in subsequent numbers; continued in Entomologica Americana, Vols. I–III, and not yet completed.

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Gives synoptic tables of Monachus, p. 195; Diachus, p. 196; Triachus, p. 197; Bassareus, p. 198; Cryptocephalus, p. 199; Pachybrachys, p. 204.

George H. Horn.—Miscellaneous notes and short studies of North American Coleoptera, Chrysomelidæ, Hispini. <Trans. Amer. Ent. Soc., Vol. X, 1883, pp. 290–303.

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Geo. H. Horn.—Revision of the Bruchidæ of the United States. <Trans. Amer. Ent. Soc., Vol. IV, 1873, pp. 311–342.

TENEBRIONIDÆ.

Geo. H. Horn.—Revision of the Tenebrionidæ of America, north of Mexico. <Trans. Amer. Philos. Soc., n. ser., Vol. XIV, 1870, pp. 253–404, 2 plates.

CISTELIDÆ.

This family has never been monographed, and we have only tables of the genera Hymenorus and Mycetochares, by Le Conte, in "New Species of North American Coleoptera" (Smithson. Misc. Contrib., etc., p. 135); and Trans. Amer. Philos. Soc., XVII, 1878, p. 616.

OTHNIIDÆ.

The few species of the single genus constituting this family have been tablulated by Dr. Horn in Trans. Amer. Ent. Soc., Vol. II, 1868, pp. 132, 133.

LAGRIIDÆ.

Geo. H. Horn.—Miscellaneous Coleopterous studies. <Trans. Amer. Ent. Soc., Vol. XV., 1888.

Contains on pp. 28–32 a synopsis of the family.

MONOMMIDÆ.

JAMES THOMSON.—Monographie de la famille des Monommides. <Ann. Soc. Ent. France, 1860, pp. 5–38.

A monograph of the family of the whole world. The few (four) species hitherto found in North America are tabulated by Dr. Horn in Trans. Amer. Ent. Soc., Vol. IV, 1872, p. 150.

MELANDRYIDÆ.

No complete synopsis has hitherto been published, and excepting a table of Hallomenus, by Dr. Le Conte (Proc. Amer. Philos. Soc., Vol. XVII, 1878, p. 619), we can only record the following paper .

GEORGE H. HORN.—Notes on the Mycteridæ and other Heteromera. <Trans. Amer. Ent. Soc., Vol. VII, 1879, pp. 336–339.

Tabulates Mycterus and Lacconotus.

GEO. H. HORN.—Miscellaneous Coleopterous studies. <Trans. Amer. Ent. Soc., Vol. XV., 1888.

Contains on pp. 32–44 a revised table of the tribes of Melandryidæ and tables of the genera Eustrophus, Holostrophus, Orchesia, and Hypulus.

PYTHIDÆ.

Excepting the table of Cononotus, by Dr. Horn (Trans. Am. Ent. Soc., Vol. II, 1868, p. 136), and a table of Pytho, by the same author (l. c. Vol. XV, 1888, p. 45), we have no synoptic papers on this family.

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JOHN L. LE CONTE.—Synopsis of the Œdemeridæ of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VII, 1854, pp. 20–22.

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The few species composing this family are tabulated by Dr. Le Conte in Mr. E. P. Austin's Catalogue of the Coleoptera of Mount Washington, N. H. <Proc. Boston Soc. Nat. Hist., Vol. XVI, 1874, pp. 265–276.

MORDELLIDÆ.

JOHN L. LE CONTE.—Synopsis of the Mordellidæ of the United States. <Proc. Ac. Nat. Sc. Phil., 1862, pp. 43–51.

JOHN B. SMITH.—A synopsis of the Mordellidæ of the United States. <Trans. Amer. Ent. Soc., Vol. X, 1882, pp. 73–100, Plates I–III.

RHIPIPHORIDÆ.

JOHN L. LE CONTE.—Note on the species of Myodites Latr., inhabiting the United States. <Proc. Ac. Nat. Sc. Phil., 1865, pp. 96–98. See also "Short Studies of North American Coleoptera." <Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 210.

GEORGE H. HORN.—Notes on the species of Rhipiphorus of the United States. <Trans. Amer. Ent. Soc., Vol. V, 1875, pp. 121–125.

ANTHICIDÆ.

F. de la Ferté-Sénectère.—Monographie des Anthicus et genres voisins, Coléoptères hétéromères de la tribus des Trachélides. Paris, 1848.

John L. Le Conte.—Synopsis of the Anthicites of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VI, 1852, pp. 91–104.

John L. Le Conte.—Synopsis of the Pyrochroidæ of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VII, 1855, pp. 270–275.

The tribes Pedilini, Xylophilini, and Macratrini, formerly attached to the Pyrochroidæ, are here treated.

George H. Horn.—Synopsis of the species of Corphyra Say, of the United States. <Trans. Amer. Ent. Soc., Vol. III, 1871, pp. 278–283.

For subsequent tables by Dr. Horn of the same genus see Trans. Amer. Ent. Soc., Vol. V, 1874, p. 40, and, *l. c.*, Vol. X, 1883, pp. 305–310.

PYROCHROIDÆ.

John L. Le Conte.—Synopsis of the Pyrochroidæ of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VII, 1855, pp. 270–275.

George H. Horn.—Miscellaneous Coleopterous studies. <Trans. Amer. Ent. Soc., Vol. XV, 1888.

Contains on p. 47 a table of Dendroides.

MELOIDÆ.

John L. Le Conte.—Synopsis of the Meloides of the United States. <Proc. Ac. Nat. Sc. Phil., Vol. VI, 1853, pp. 328–350.

George H. Horn.—Revision of the species of several genera of Meloidæ of the United States. <Proc. Am. Philos. Soc., Vol. XIII, 1873, pp. 88–117.

Gives tables of Macrobasis, p. 88; Epicauta, p. 95; Cantharis, p. 103; Pomphopœa, p. 115.

RHYNCHOPHORA.

C. J. Schœnherr.—Genera et species Curculionidum cum synonymia hujus familiæ... 8 vols., Paris, 1833–'34.

An additional volume, Mantissa secunda familiæ Curculionidum, appeared in 1847.

A monograph of the Rhynchophora (including the Bruchidæ) of the whole world but now antiquated.

C. Zimmermann.—Synopsis of the Scolytidæ of America, north of Mexico. With Notes and an Appendix by J. L. Le Conte. <Trans. Amer. Ent. Soc., Vol. II, 1868, pp. 141–178.

GEORGE H. HORN.—The Brenthidæ of the United States. <Trans. Amer. Ent. Soc., Vol. IV, 1872, pp. 127-129.

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JOHN B. SMITH.—Synopsis of the Apioninæ of North America. <Trans. Amer. Ent. Soc., Vol. XI, 1874, pp. 41–68, 3 plates.

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A monograph of the North American Rhynchophora.

FREDERICK BLANCHARD.—Table of Balaninus Germ. <Bull. Brook. Ent. Soc., Vol. VII, 1884, pp. 106–108.

LEPIDOPTERA.

I.—CATALOGUES AND LISTS.

J. G. **Morris**.—Catalogue of the described Lepidoptera of North America. Washington, Smithsonian Institution, 1860.

This is the first catalogue of the North American Lepidoptera, but now greatly antiquated and superseded.

J. W. **Weidemeyer**.—Catalogue of North American Butterflies. <Proc. Entom. Soc. Phil., Vol. II, 1863–'66, pp. 143–154 and 513–542.

Superseded by subsequent papers.

A. R. **Grote and** C. T. **Robinson**.—A synonymical catalogue of North American Sphingidæ, with notes and descriptions. <Proc. Entom. Soc. Phil., Vol. V, 1865, pp. 149–193, 3 plates.

Gives full and complete synonymy, with descriptions of several new genera and species.

A. R. **Grote and** C. T. **Robinson**.—List of the Lepidoptera of North America. Philadelphia, Amer. Ent. Soc., 1868.

Contains the Sphingidæ, Ægeriidæ, Thyridæ, Zygænidæ, and Bombycidæ.

A. R. **Grote**.—List of the Noctuidæ of North America. <Bull. Buffalo Soc. Nat. Hist., Vol. II, 1874, pp. 1–77.

The only synonymical and bibliographical catalogue of the North American Noctuidæ.

S. H. **Scudder**.—Synonymic list of the Butterflies of North America, north of Mexico. Part I. Nymphales. <Bull. Buff. Soc. Nat. Hist., Vol. II, 1875, pp. 233–269; Part II. Rurales. <*L. c.*, Vol. III, 1876, pp. 98–129.

Contains a very complete synonymy, but its classification has not been adopted by subsequent writers.

W. F. **Kirby**.—A synonymic catalogue of diurnal Lepidoptera. London, 1871; Supplement, London, 1877.

A complete synonymical list of the diurnals of the world.

B. **Gerhard**.—Systematisches Verzeichniss der Macrolepidopteren von Nord-Amerika. Leipzig, 1878.

Merely a check-list and not reliable.

H. **Strecker**.—Butterflies and Moths of North America. Diurnes. Reading, Pa., 1878.

A very complete synonymical and annotated catalogue, with glossary of terms and an introductory chapter giving directions for collecting, preserving, and shipping butterflies.

V. T. **Chambers.**—Index to the described Tineina of the United States and Canada. <Bull. U. S. Geol. Survey Terr., Vol. IV, 1878, pp. 125–167.

An annotated catalogue, with descriptions of many new species.

Brooklyn Entomological Society.—Check-list of the Macrolepidoptera of America, north of Mexico. Brooklyn, N. Y., 1882.

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A list of all heterocerous Macrolepidoptera; also the Pyralidæ and Tortricidæ. Supersedes several previous lists by the same author.

C. H. **Fernald.**—A synonymical catalogue of the described Tortricidæ of North America, north of Mexico. <Trans. Amer. Ent. Soc., Vol. X, 1882, pp. 1–64; also separate.

W. H. **Edwards.**—Revised catalogue of the Diurnal Lepidoptera of America north of Mexico. <Trans. Amer. Entom. Soc., Vol. XI, 1884, pp. 245–338.

This is the most recent reference and synonymic catalogue, superseding a similar catalogue by the same author published in 1877.

W. H. **Edwards.**—List of species of the Diurnal Lepidoptera of America north of Mexico. Boston, Houghton, Mifflin & Co., 1884, 4to.

A mere list of the species, following in all respects the catalogue just cited, and printed to accompany Vol. II of the "Butterflies of North America."

II.—GENERAL WORKS ON CLASSIFICATION.

G. A.W. **Herrich-Schaeffer.**—Sammlung neuer oder wenig bekannter aussereuropäischer Schmetterlinge. Vol. I. Regensburg, 1850–'58; Vol. II, Pt. 1, 1869.

Contains a classification of the Lepidoptera, which forms the basis of our present arrangement.

John G. **Morris.**—Synopsis of the described Lepidoptera of North America. Part I. Diurnal and Crepuscular Lepidoptera. Washington, Smithsonian Institution, 1862.

Compiled descriptions of the North American Lepidoptera, from the Rhopalocera to the Bombycidæ.

H. **Strecker.**—Lepidoptera, Rhopaloceres et Heteroceres, indigenous and exotic; with descriptions and colored illustrations. Reading, Pa., 1872–'77.

Fifteen parts of this work have been published containing figures and descriptions of many North American species.

John B. **Smith.**—An introduction to a classification of the North American Lepidoptera. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, pp. 70–74 and 81–83.

A synopsis of the families of Lepidoptera, based on Herrich-Schaeffer's classification.

III.—MONOGRAPHS AND SYNOPSES.

Rhopalocera.

J. A. BOISDUVAL.—Histoire naturelle des Insectes. Spécies général des Lépidoptères. Suites à Buffon. Paris, 1836.

Contains full descriptions of the known species, but extends only from Papilio to the end of Terias.

E. DOUBLEDAY AND W. C. HEWITSON.—The genera of diurnal Lepidoptera, comprising their generic characters, a notice of their transformations, and a catalogue of the species of each genus; illustrated, with 86 colored plates from drawings by W. C. Hewitson. 2 vols., London, 1846-'52.

This work was completed by Westwood after the death of Doubleday.

S. H. SCUDDER.—Butterflies: Their structures, changes, and life-histories, with special reference to American forms. Being an application of the "Doctrine of descent" to the study of Butterflies, with an appendix of practical instructions. New York, Henry Holt & Co., 1881.

CARL PLOETZ.—Die Hesperiinen-Gatting Hesperia *Aut.* und ihre Arten. <Stettin. entom. Zeit., 1882, pp. 314-344, continued in subsequent volumes.

JOHN B. SMITH.—Synopsis of the genera of the North American Rhopalocera. <Bull. Brookl. Ent. Soc., Vol. VI, 1883, pp. 37-45.

A tabular synopsis embracing all North American genera.

C. H. FERNALD.—The Butterflies of Maine. Designed for the use of the students in the Maine State College, and the farmers of the State. Orono, Me., 1884.

G. H. FRENCH.—The Butterflies of the Eastern United States. For the use of classes in Zoology and private students. Philadelphia, Lippincott & Co., 1886.

Gives synopses of the genera and species, and descriptions of the species.

BROOKLYN ENTOMOLOGICAL SOCIETY.—Synopses of Butterflies. <Bull. Brooklyn Entom. Soc., Vol. I and subsequent volumes; continued in Entomologica Americana, Vol. I.

Synopses of the North American species of Rhopalocera, the later articles giving tables of species and bibliography. Not yet completed.

SAMUEL H. SCUDDER.—Comparative tables for the families of Butterflies. <Canad. Entom. Vol. XIX, 1887, No. 11, pp. 201-206.

W. H. EDWARDS.—Butterflies of North America. Boston, Houghton, Mifflin & Co.

Two volumes are completed and the third is in course of publication.

Heterocera.

SPHINGIDÆ.

T. W. HARRIS.—Descriptive Catalogue of the North American insects belonging to the Linnæan genus Sphinx, in the cabinet of Thaddeus William Harris, M. D., librarian of Harvard University. <Amer. Journ. Sc. and Arts, Vol. XXXVI, 1839, pp. 282–320.

Includes not only the Sphingidæ as at present limited, but also the Zygænidæ of Grote's new list.

B. CLEMENS.—Synopsis of the North American Sphingides. <Journ. Ac. Nat. Sc. Phil., Vol. IV, Pt. 2, 1859, pp. 97–190.

A monograph of the family as at present limited.

J. A. BOISDUVAL.—Sphingides, Sesiides, Castniides. Paris, Roret 1874.

Forms part of the Suites à Buffon, and is Vol. I of the Spécies général des Lépidoptères hétérocères.

A. G. BUTLER.—Revision of the Heterocerous Lepidoptera of the family Sphingidæ. <Trans. Zool. Soc. London, Vol. IX, 1877, pp. 511–644, Pl. XC–XCIV.

A descriptive catalogue.

JOHN B. SMITH.—An introduction to a classification of the North American Lepidoptera. Sphingidæ. <Entom. Amer., Vol. I, 1885, pp. 81–87.

Contains a synopsis of the genera, with brief remarks on each.

C. H. FERNALD.—The Sphingidæ of New England. Orono, Me., 1886.

Gives the life-history, so far as known, of all species recorded from New England.

JOHN B. SMITH.—A monograph of the Sphingidæ of North America, north of Mexico. <Trans. Amer. Ent. Soc., Vol. XV, 1888, Part II, 12 plates.

[This is not published but is included here because now in the printer's hands.—C. V. R.]

SESIIDÆ.

See papers by Harris and Boisduval above cited, who treat the Sesiidæ as a part of the Sphingidæ, both works being antiquated so far as they relate to the Sesiidæ.

JOHN B. SMITH.—An introduction to a classification of the North American Lepidoptera. <Entom. Amer., Vol. IX., 1888, pp. 9–13.

THYRIDÆ.

This family has also been treated by Harris and Boisduval as a part of the Sphingidæ.

ZYGÆNIDÆ.

A. S. PACKARD, Jr.—Notes on the family Zygænidæ. <Proc. Essex Institute, Vol. IV, 1864, pp. 7–47, Pl. I, II.

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JASSIDÆ (including the *Tettigoniidæ*).

V. SIGNORET.—Revue iconographique des Tettigonides. <Ann. Soc. Entom. de France, 1853–'55, with colored plates.

V. SIGNORET.—Essai sur les Jassides Stål, Fieb. et plus particulièrement sur les Acocéphalides Puton. <Ann. Soc. Entom. France, 1879–'80.

E. TASCHENBERG.—Zur Kenntniss der Cicadellinen-Gattung Tettigonia Geoff. <Zeitschr. für Naturw., Vol. V, 1884.

CHARLES W. WOODWORTH.—Jassidæ of Illinois. Part I. <Bulletin Ill. State Labor. Nat. Hist., Vol. III, Art. II, 1887.

CERCOPIDÆ.

V. SIGNORET.—Revue critique du groupe des Tettigonides et de la tribu des Cercopides. <Revue et Mag. de Zool., Vol. V, 1853, pp. 173–184.

FULGORIDÆ.

J. O. WESTWOOD.—On the family Fulgoridæ, with a monograph of the genus Fulgora of Linnæus. <Trans. Linn. Soc. London, Vol. XVIII, 1839, pp. 133–238, 1 pl.

C. STÅL.—Die amerikanischen Fulgoriden-Gattungen synoptisch beschrieben. <Stettiner entomol. Zeit., Vol. XXXI, 1870, pp. 255–258.

MEMBRACIDÆ.

C. STÅL.—Bidrag till Membracidernas Kännedom. <Oefvers. af Kongl. Vet.-Akad. Förhandl., 1869.

PSYLLIDÆ.

FRANZ LÖW.—Zur Systematik der Psylloden. <Verh. d. k. k. zool. bot. Ges. in Wien, Jahrgany 1878, pp. 585–610.

Characteristics and tables of the European subfamilies and genera. Supersedes all previous classifications.

WM. H. ASHMEAD.—On the Aphididæ of Florida, with descriptions of new species. Family Psyllidæ. <Canad. Entom., Vol. XIII, 1881, pp. 220–225.

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BENJ. D. WALSH.—On the genera of Aphidæ found in the United States. <Proc. Ent. Soc. Phil., Vol. I, 1861–'63, pp. 294–310.

CYRUS THOMAS.—Notes of the Plant-lice found in the United States. <Trans. Ill. Hortic. Soc., 1877, pp. 137–212.

A review of the family, including the Psyllidæ; reproduces the descriptions of earlier authors, and adds descriptions of new species.

CYRUS THOMAS.—A list of the species of the tribe Aphidini, family Aphidæ, found in the United States, which have been heretofore named, with descriptions of some new species. <Illinois State Laboratory of Nat. History, Bulletin No. 2, 1878, pp. 3–16.

CH. V. RILEY AND J. MONELL.—Notes on the Aphididæ of the United States, with descriptions of species occurring West of the Mississippi. <Bull. U. S. Geol. and Geogr. Survey of the Terr., Vol. V, No. 1, 1879, pp. 1–32, 2 pl.

Riley gives the biology and description of several Pemphiginæ; Monell, descriptions, with occasional tables, of a number of Aphidinæ.

CYRUS THOMAS.—Eighth Report of the State Entomologist on the noxious and beneficial insects of the State of Illinois. Third Annual Report, by Cyrus Thomas, Springfield, 1879.

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GEO. B. BUCKTON.—Monograph of the British Aphides. 4 vols. Ray Society, London, 1875–'83.

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O. W. OESTLUND.—Synopsis of the Aphididæ of Minnesota. <Bull. No. 4 Geol. and Nat. Hist. Survey of Minn., Saint Paul, 1887.

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V. SIGNORET.—Essai sur les Cochenilles. <Ann. Soc. Ent. de France, 1868–'76.

J. H. COMSTOCK.—Report on Scale Insects. <Annual Report of the Commissioner of Agriculture for the year 1880, Washington, 1881, pp. 276–349, plates.

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H. Denny.—Monographia Anoplurorum Britanniæ, or an essay on the British species of parasitic insects. London, 1842, 26 plates.

C. G. A. Giebel.—Insecta epizoa. Die auf Saügethieren und Vögeln schmarotzenden Insekten. Nach Zeichnungen von C. L. Nitzsch. Leipzig, 1874, 20 plates.

Andrew Murray.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks. London and New York, 1877.

The Pediculidæ are treated on pp. 384–400.

P. Mégnin.—Les Parasites et les maladies parasitaires chez l'homme, les animaux domestiques et les animaux sauvages avec lesquels ils peuvent être en contact. Insectes, Arachnides, Crustacés. Paris, 1880.

The Pediculidæ are treated on pp. 72–79.

E. Piaget.—Les Pediculines. Description de toutes les espèces observées, enrichie d'espèces nouvelles. Leide, 1880, 56 plates; Supplement, 1885, 17 plates.

ORTHOPTERA.

I.—CATALOGUES.

Samuel H. Scudder.—A catalogue of the Orthoptera of North America described previous to 1867. Smithsonian Institution. Miscellaneous Collections 189, 1868.

An alphabetical, not synonymical, list of the Orthoptera described from North America; contains also a full bibliography up to 1867.

J. Sidney Smith.—Orthoptera of the State of Maine. <Proc. Portland Soc. Nat. Hist., 1868, pp. 143–151.

A synonymical catalogue of the Orthoptera found in Maine, with notes on habits and distribution of the species.

Cyrus Thomas.—A list of the Orthoptera of Illinois. <Bull. Ills Mus. Nat. Hist., No. 1, 1876, pp. 59–69.

A synonymical list of the Orthoptera found in Illinois.

II.—GENERAL WORKS ON CLASSIFICATION.

J. G. Audinet-Serville.—Histoire naturelle des Insectes Orthoptères. Paris, 1839, 776 pp., 14 plates.

Natural history of the order up to date, with bibliography and list of species described.

Henri de Saussure.—Orthoptera nova Americana (Diagnoses præliminares). Series I–III. <Revue et Mag. de Zool., 1859–'61.

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Contains synoptical tables and a review of the system used for classification.

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Samuel H. Scudder.—Synoptical tables for determining North American insects. Orthoptera. <Psyche, Vol. I, 1876, pp. 169–171.

Synopsis of the families of Orthoptera; also a list of useful works in the study of North American Orthoptera.

III.—SYNOPSES OF FAMILIES OR SUBFAMILIES.

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A. H. HALIDAY.—An Epitome of the British genera in the Order Thysanoptera, with indications of a few of the species. <Entomol. Mag., Vol. III, 1836, pp. 439–451.

FRANCIS WALKER.—List of specimens of Homopterous Insects in the collection of the British Museum. 5 vols. and 1 vol. Supplement. London, 1850–'58.

The Physapoda, compiled from Haliday's manuscripts are treated in the supplement.

These are the only classificatory papers on this family. No systematic paper on the North American Physapods has hitherto been published, and only a few species are described by various authors.

FORFICULIDÆ.

H. DOHRN.—Versuch einer Monographie der Dermapteren. <Stettiner entomol. Zeit., Vols. XXIV–XXVI, 1863–'65.

A monograph of the Forficulidæ of the whole world.

SAMUEL H. SCUDDER.—Synoptical tables for determining North American insects. Orthoptera. U. S. Forficulariæ. <Pysche, Vol. I, 1876, pp. 177, 178.

Tabulates thirteen species and gives a list of books useful for the study of the family.

SAMUEL H. SCUDDER.—Brief Synopsis of North American Earwigs, with an appendix on the fossil species. <Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. II, No. 3, 1876, pp. 249–260.

SAMUEL H. SCUDDER.—Critical and historical notes on Forficulariæ, including descriptions of new generic forms and an alphabetical synonymic list of the described species. <Proc. Bost. Soc. Nat. Hist. July–Oct., 1876, Vol. XVIII, pp. 287–332.

BLATTIDÆ.

HENRI DE SAUSSURE.—Orthoptera nova Americana (Diagnoses præliminares). Ser. III. <Revue et Mag. de Zool., 1862.

Contains descriptions of new Blattidæ, with synoptical arrangement.

C. BRUNNER VON WATTENWYL.—Nouveau système des Blattaires. Vienna, 1865, 426 pp., 13 plates.

Synoptical arrangement of all described species, with descriptions of many new ones; also bibliography on the family.

HENRI DE SAUSSURE.—Mélanges Orthoptérologiques. 6 fascicules. Genève, 1863–'78.

Fascicule II contains the Blattidæ.

C. STÅL.—Recherches sur le système des Blattaires. Stockholm, 1874.

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George R. Gray.—Synopsis of the species of insects belonging to the family of Phasmidæ. London, 1835.

J. O. Westwood.—A catalogue of the Orthopterous insects in the British Museum. Part I. Phasmidæ. London, 1859.

C. Stål.—Recensio Orthopterorum. Revue critique des Orthoptères décrits par Linné, De Geer et Thunberg. Part 3. Stockholm, 1875.

Synoptical tables of the genera of Phasmidæ, with notes on many species.

MANTIDÆ.

Henri de Saussure.—Essai d'un système des Mantides. <Mittheil. d. schweiz. ent. Ges., Vol. III, 1869, pp. 49–73.

Classification of the Mantidæ. Part 2 contains descriptions of North American species.

Henri de Saussure.—Additions au système des Mantides. Genève, 1871.

Synoptic table of genera and species of North American Mantidæ.

Henri de Saussure.—Mantides américains. Genève, 1871, 186 pp., 2 pl.

A synopsis of the North American species.

C. Stål.—Recherches sur le système des Mantides. Stockholm, 1873.

GRYLLIDÆ.

Samuel H. Scudder.—Revision of the large, stylated, fossorial crickets. <Memoirs of the Peabody Academy of Sciences, Vol. I, No. 1, 1869.

Descriptions of the species of Scapteriscus and Gryllotalpa.

Henri de Saussure.—Mélanges Orthoptérologiques. Gryllides. Two parts. Genève, 1877–'78.

A monograph of the family, containing synoptical tables of the genera and species.

LOCUSTIDÆ.

C. Stål.—Recensio orthopterorum. Revue critique des orthoptères décrits par Linné, De Geer et Thunberg. (Part 2.) Stockholm, 1874.

Contains synoptical tables of the genera.

C. Brunner von Wattenwyl.—Monographie der Phaneropteriden. Wien, 1878, 402 pp., 8 pl.

A synoptical monograph of the Katydids of the world, with full bibliography and full synonymy of the species.

Ignacio Bolivar.—Arthropodos del Viage al Pacifico, verificado de 1862–1865 por una comision de naturalistas enviada por el Gobierno Español. Insectes neuropteros y ortopteros. Madrid, 1884, 114 pp., 3 pl.

Contains a synoptical table of the genus Conocephalus, with descriptions of new species.

ACRIDIDÆ.

C. STÅL.—Recensio Orthopterorum. Revue critique des Orthoptères décrits par Linné, De Geer et Thunberg. Part 1. Acrididæ. Stockholm, 1873.

A synoptical arrangement of the genera of the family, with descriptions of new genera and species.

CYRUS THOMAS.—Synopsis of North American Acrididæ. <Report U. S. Geol. Survey, Vol. V, Part 1, 1873.

A systematical arrangement of the described species of North American locusts: Part 1. Species of the United States; Part 2. Species from other parts of North America.

SAMUEL H. SCUDDER.—Spharagemon, a genus of Œdipodidæ; with a revision of the species. <Proc. Boston Soc. Nat. Hist., Vol. XVII, 1875, pp. 467–471. Separate, under the title: Entomol. Notes, IV, pp. 66–70.

A synopsis of the genus, with descriptions of new species.

SAMUEL H. SCUDDER.—A revision of two American genera of Œdipodidæ. <Proc. Boston Soc. Nat. Hist., Vol. XVII, 1875, pp. 478–485. Separate, under the title: Entomol. Notes, Vol. IV, pp. 77–84.

A synopsis of the genera Encoptolophus and Tragocephala.

CYRUS THOMAS.—Manual of economic entomology. Part III. The Acrididæ of Illinois. <Ninth Report of the State Entomologist . . . of the State of Illinois, 1880, pp. 73–140.

Contains a synoptical table or key to the families of Orthoptera, a key to the subfamilies and genera, and a key to the Illinois species of Acrididæ.

LAWRENCE BRUNER.—North American Acrididæ, north of Mexico. <Third Report U. S. Entomolog. Commission, 1883, pp. 55–61.

A systematical list of the species described from North America.

HENRI DE SAUSSURE.—Prodromus Œdipodiorum Insectorum ex ordine Orthopterorum. Genève, 1884, 4to, 254 pp.

A synoptical monograph of the subfamily Œdipodinæ of all countries, with descriptions of new species.

NEUROPTERA (INCLUDING PSEUDONEUROPTERA).

I.—CATALOGUES.

No catalogue of the North American Neuroptera—not even a partial one—has ever been published.

II.—GENERAL WORKS ON CLASSIFICATION.

HERMANN BURMEISTER.—Handbuch der Entomologie. Berlin, 1832–'35.

The Neuroptera are treated in Vol. II, Part I.

P. RAMBUR.—Histoire naturelle des Neuroptères. Suites à Buffon. Paris, 1842.

HERMANN HAGEN.—Synopsis of the Neuroptera of North America, with a list of the South American species. Prepared for the Smithsonian Institution. Smithsonian Miscellaneous Collections, Washington, 1861.

III.—MONOGRAPHS AND SYNOPSES.

TERMITIDÆ.

H. A. HAGEN.—Monographie der Termiten. <Linnæa entomol., Vols. X, XII, and XIV, 1855–'60.

EMBIIDÆ.

H. A. HAGEN.—Monograph of the Embidina. <Canadian Entomol. Vol. XVII, 1885.

Only one species of this family has hitherto been found in the United States.

PSOCIDÆ.

H. A. HAGEN.—Beiträge zur Monographie der Psociden. <Stettiner entomol. Zeit., Vols. XLIII and XLIV, 1882–'83.

PERLIDÆ.

F. J. PICTET.—Histoire naturelle générale et particulière des insectes Neuroptères. Première monographie: Famille des Perlides. Genève, 1841–'42.

EPHEMERIDÆ.

F. J. PICTET.—Histoire naturelle générale et particulière des insectes Neuroptères. Seconde monographie: Famille des Ephémérines. Genève, 1843–'45.

BENJ. D. WALSH.—List of the Pseudoneuroptera of Illinois contained in the cabinet of the writer, with descriptions of over forty new species, and notes on their structural affinities. <Proc. Ac. Nat. Sc. Philadelphia, 1862, pp. 361–402.

This paper contains, on pp. 367, 368, a table of the genera of Ephemeridæ.

BENJ. D. WALSH.—Observations on certain North American Neuroptera, by H. Hagen, M. D., of Koenigsberg, Prussia; translated from the original French MS., and published by permission of the author, with notes and descriptions of about twenty new North American species of Pseudoneuroptera. <Proc. Entom. Soc. Phila., Vol. II, 1863–'64, pp. 167–272.

Contains a modification of the table of genera of Ephemeridæ, pp. 195, 196; a table of the subgenera of Gomphus, p. 253; and a "Synoptical table of the subfamilies of the family Odonata," pp. 259, 260.

A. E. EATON.—A monograph on the Ephemeridæ. Part 1. The nomenclature of the Ephemeridæ. <Trans. Entom. Soc. London, 1871, pp. 1–164, 6 pl.

A. E. EATON.—A Revisional Monograph of recent Ephemeridæ, or Mayflies. <Trans. Linn. Soc. London, 1883–'86.

Four parts have hitherto been published.

ODONATA.

E. DE SELYS LONGCHAMPS ET H. HAGEN.—Monographie des Caloptérygines. Bruxelles, 1854.

E. DE SELYS LONGCHAMPS ET H. HAGEN.—Monographie des Gomphines. Bruxelles, 1858.

E. DE SELYS LONGCHAMPS.—Synopsis des Agrionines. 6 parts. Bruxelles, 1860–'65.

E. DE SELYS LONGCHAMPS.—Synopsis des Cordulines. Bruxelles, 1871.

H. A. HAGEN.—Synopsis of the Odonata of America. <Proc. Boston Soc. Nat. Hist., Vol. XVIII, 1875, pp. 20–96.

Omitting the subfamily Agrionina.

HEMEROBIDÆ.

G. TH. SCHNEIDER.—Symbola ad monographiam generis Chrysopæ Leach. Vratislaviæ, 1851.

H. A. HAGEN.—Hemerobidarum synopsis synonymica. <Stettiner entomol. Zeit., 1866, pp. 369–462.

H. A. HAGEN.—Monograph of the Hemerobidæ. <Part I, Proc. Boston Soc. Nat. Hist., Vol. XXIII, 1886, pp. 250–269; Pt. II, *l. c.*, pp. 276–292.

Apparently not yet completed.

PANORPIDÆ.

J. O. WESTWOOD.—Monograph of the genus Panorpa. <Trans. Entom. Soc. London, Vol. IV, p. 1.

PHRYGANIDÆ.

R. MCLACHLAN.—Notes on North American Phryganidæ, with especial reference to those contained in the collection of the British Museum. <Entom. Annual for 1863, pp. 155–163.

Contains a list of North American Phryganids.

H. A. HAGEN.—Phryganidarum Synopsis synonymica. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XIV, 1864, pp. 799–890.

H. A. HAGEN.—Beiträge zur Kenntniss der Phryganiden. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXIII, 1873, pp. 377–452.

H. A. HAGEN.—[On the Phryganidæ.] <Proc. Boston Soc. Nat. Hist., Vol. XV, 1873, pp. 384, 385.

A list of the North American species.

A. E. EATON.—On the Hydroptilidæ, a family of the Trichoptera <Trans. Entom. Soc. London, 1873, pp. 125–151.

Gives a list of the species, and synopsis of genera.

MALLOPHAGA.

H. DENNY.—Monographia Anoplurorum Britanniæ. London, 1842, 26 pl.

C. G. A. GIEBEL.—Insecta epizoa. Die auf Säugethieren und Vögeln schmarotzenden Insekten. Nach Zeichnungen von C. L. Nitzsch. Leipzig, 1874, 20 pl.

ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks. London and New York, 1877.

The Mallophaga (Anoplura) are treated on pp. 375–384.

P. MÉGNIN.—Les Parasites et les maladies parasitaires chez l'homme, les animaux domestiques et les animaux sauvages avec lesquels ils peuvent être en contact. Insectes, Arachnides, Crustacés. Paris, 1880.

E. PIAGET.—Les Pédiculines. Description de toutes les espèces observées, enrichie d'espèces nouvelles. Leide, 1880, 56 pl.; Supplement, 1885, 17 pl.

O. TASCHENBERG.—Die Mallophagen mit besonderer Berücksichtigung der von Meyer gesammelten Arten. Halle, 1882.

THYSANURA.

A. S. PACKARD, Jr.—Synopsis of the Thysanura of Essex County, Mass., with descriptions of a few extralimital forms. <Fifth Annual Report of the Trustees of the Peabody Academy of Science for the year 1872, Salem, 1873, pp. 23–51.

JOHN LUBBOCK.—Monograph of the Collembola and Thysanura. London, Ray Society, 1873.

The introduction gives the full bibliography up to date.

ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks, London and New York, 1877.

The Thysanura are treated of on pp. 401–416.

MYRIAPODA.

I.—CATALOGUES.

No comprehensive catalogue or list have hitherto been published on the North American Myriapods.

II.—COMPREHENSIVE WORKS.

THOMAS SAY.—Descriptions of the Myriapodæ of the United States. <Journ. Ac. Nat. Sc. Phil., Vol. II, 1821, pp. 102–114; Say's Entom. Writings, ed. Le Conte, Vol. II, pp. 24–32.

This is the first paper of importance on the North American Myriapoda.

GEORGE NEWPORT.—Monograph of the class Myriapoda, Order Chilopoda. <Trans. Linnean Soc. of London, Vol. XIX, 1845, pp. 265–302 and 349–439.

C. L. KOCH.—System der Myriapoden. Regensburg, 1847.

C. L. KOCH.—Die Myriapoden. 2 vols. Halle, 1863.

HORATIO C. WOOD, Jr.—On the Chilopoda of North America, with Catalogue of all the specimens in the collection of the Smithsonian Institution. <Journ. Ac. Nat. Sc. Phil., New Ser., Vol. V, 1863, pp. 5–42.

HORATIO C. WOOD, Jr.—The Myriapoda of North America. <Trans. Amer. Philos. Soc., Vol. XIII, 1865, pp. 137–248, 3 pl.

This is the first and only monograph of the Myriapoda published in this country.

ANDREW MURRAY.—Economic Entomology. Aptera. South Kensington Museum Science Handbooks, London and New York, 1877.

ROBERT LATZEL.—Die Myriapoden der Oesterreichisch-Ungarischen Monarchie. Erste Hälfte: Die Chilopoden, Wien, 1880. Zweite Hälfte: Die Symphylen, Pauropoden und Diplopoden, Wien, 1884.

The most recent comprehensive work on this order, and very important from a classificatory standpoint.

A. S. PACKARD, Jr.—On the morphology of the Myriapoda. <Proc. Amer. Philos. Soc., Vol. XXI, 1883, pp. 197–209.

LUCIEN M. UNDERWOOD.—The North American Myriapoda. <Entomol. Amer., Vol. I, 1885, pp. 141–151.

A complete bibliographical review of the subject, with tables of families and genera.

III.—MONOGRAPHS AND SYNOPSES OF FAMILIES AND GENERA.

PAUROPODA (families *Pauropodidæ* and *Eurypauropodidæ*).

A. S. PACKARD, Jr.—New or rare Neuroptera, Thysanura, and Myriapoda. < Proc. Boston Soc. of Nat. Hist., Vol. XIII, 1870, pp. 405–411

A. S. PACKARD, Jr.—A remarkable Myriapod. <Amer. Natur., Vol. IV, 1870, p. 621.

JOHN A. RYDER.—Discovery of two remarkable genera of minute Myriapoda in Fairmount Park. <Amer. Natur., Vol. XII, 1878, pp. 557, 558.

JOHN A. RYDER.—An account of a new genus of minute Pauropod Myriapods. <Amer. Natur., Vol. XIII, 1879, pp. 603–612.

DIPLOPODA (families *Polyxenidæ*, *Polyzonidæ*, *Polydesmidæ*, *Chordeumidæ*, *Lysiopetalidæ*, and *Julidæ*).

HORATIO C. WOOD.—Descriptions of new species of North American Polydesmidæ. <Proc. Ac. Nat. Sc. Phil., 1864, pp. 6–10.

JOHN A. RYDER.—List of the North American species of Myriapods belonging to the family of the Lysiopetalidæ, with a description of a blind form from Luray Cave, Virginia. <Proc. U. S. Nat. Mus., Vol. III, 1881, pp. 524–529.

A. S. PACKARD, Jr.—A revision of the Lysiopetalidæ, a family of Chilognath Myriapoda, with a notice of the genus Cambala. <Proc. Amer. Philos. Soc., Vol. XXI, 1883, pp. 177–197.

CHARLES H. BOLLMAN.—Notes on North American Julidæ, with descriptions of new species. <Ann. N. Y. Ac. Sc., Vol. IV, Nos. 1 and 2, pp. 25–44.

CHILOPODA (families *Scutigeridæ*, *Geophilidæ*, *Scolopendridæ*, and *Lithobiidæ*).

LUDWIG KOCH.—Die Myriapodengattung Lithobius. Nürnberg, 1862.
A monograph of the genus, comprising the species of all continents.

A. STUXBERG.—Nya nordamerikanska Lithobier. <Öfversigt k. Vetensk. Acad. Förh., Vol. XXXII, No. 2, 1875, pp. 65–72.

A. STUXBERG.—Lithobioidæ Americæ borealis. Öfversigt af Nord-Amerikas hittills kända Lithobiider. <Öfversigt k. Vetensk. Acad. Förh., Vol. XXXII, No. 3, 1875, pp. 23–32.

FR. MEINERT.—Myriopoda Musei Cantabrigensis, Mass. Part I. Chilopoda. <Proc. Amer. Philos. Soc., 1885, pp. 161–233.
Of great value for the study of classification, though containing no synopses.

ARACHNIDA.

I.—*CATALOGUES.*

No catalogue of the North American forms has so far been published.

II.—*COMPREHENSIVE WORKS.*

C. W. HAHN AND C. L. KOCH.—Die Arachniden. Nürnberg, 1831–'48, 16 vols. with 563 pl.

H. LUCAS.—Descriptions et figures d'espèces nouvelles d'Arachnides. Paris, 1835–'36.

C. A. DE WALCKENAER.—Histoire naturelle des Insectes (Suites à Buffon). Aptères. Paris, Roret, 1837–'47, 4 vols., with 52 pl.

The first work on general classification of this order, and many North American species are described from drawings by Bosc and Abbot.

N. M. HENTZ.—Descriptions and figures of the Araneides of the United States. <Journ. Boston Soc. Nat. Hist., Vol. IV–VI, 1842–'50.

These papers form the basis of the study of American arachnology. Numerous species are described, but not in synoptic form.

T. THORELL.—On European Spiders. Part I. Review of the European genera of Spiders. Upsala, 1869–'70.

N. M. HENTZ.—Araneæ Americæ septentrionalis. The Spiders of the United States. Edited by J. H. Emerton and E. Burgess. <"Occasional Papers" of the Boston Society of Natural History, 1875.

A reprint of Hentz's papers on North American spiders.

GRAF EUGEN KEYSERLING.—Amerikanische Spinnen aus den Familien Pholcoidæ, Scytodoidæ und Dysderoidæ. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXVII, 1877, pp. 205–234.

GRAF EUGEN KEYSERLING.—Neue Spinnen aus Amerika. (Six parts.) <Verh. k. k. Zool.-bot. Ges. in Wien, Vols. XXIX–XXXIV, 1879–'84.

E. SIMON.—Les Arachnides de France. Paris, Vols. I–V, 1874–'84.

These two works represent the most recent systems of classification, and are therefore of great general value, although they deal only with the European fauna.

LUCIEN M. UNDERWOOD.—The Progress of Arachnology in America. <Amer. Natur., Vol. XXI, 1887, pp. 963–975.

A very useful review of the bibliography, with synoptic table of the families of the Araneæ.

III.—MONOGRAPHS AND SYNOPSES.

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BULLETIN OF THE BUFFALO SOCIETY OF NATURAL HISTORY (4 volumes completed, beginning with 1874; the fifth in course of publication).

THE CANADIAN ENTOMOLOGIST (edited by William Saunders and lately by J. S. Bethune; 19 volumes published up to the end of 1887. Published at London, Ont.)

ENTOMOLOGICA AMERICANA. Published by the Brooklyn Entomological Society at Brooklyn, N. Y. (2 volumes completed since 1885; the third in course of publication).

JOURNAL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (commencing with 1817).

MEMOIRS OF THE BOSTON SOCIETY OF NATURAL HISTORY (commencing with 1866).

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (beginning with 1841).

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PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA (6 volumes, 1861–'67).

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3. The Practical Entomologist. Vols. I and II. Published by the Entomological Society of Philadelphia, 1865–'67.
4. The American Entomologist, edited by B. D. Walsh and C. V. Riley. Vol. I. Saint Louis, Mo., 1868. (Out of print.)
5. The American Entomologist and Botanist, edited by C. V. Riley and Dr. George Vasey. Vol. II. Saint Louis, Mo., 1870.
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12. FORBES, S. A., Reports of the State Entomologist of Illinois. I–III, Springfield, 1883–'85.

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18. Reports of the Entomologists of the U. S. Department of Agriculture, T. Glover (1863–1878), J. H. Comstock (1879–1880), and C. V. Riley (1878–1879, 1880 to date).

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LIST OF ENTOMOLOGICAL WORKS PUBLISHED BY THE U. S. ENTOMOLOGICAL COMMISSION AND BY THE U. S. DEPARTMENT OF AGRICULTURE.

U. S. ENTOMOLOGICAL COMMISSION.

(Members of the Commission: C. V. Riley, A. S. Packard, jr., and Cyrus Thomas.)

Bulletin No. 1.—Destruction of the young or unfledged Locusts (*Caloptenus spretus*). (1877.) [pp. 15.]

Bulletin No. 2.—On the Natural History of the Rocky Mountain Locust and on the habits of the young or unfledged Insects as they occur in the more fertile country in which they will hatch the present year. (1877.) [pp. 14, figs. 10.]

Bulletin No. 3.—The Cotton Worm. Summary of its Natural History, with an Account of its Enemies, and the best Means of controlling it; being a Report of Progress of the Work of the Commission. By Chas. V. Riley, M. A., Ph. D. (1880.) [pp. 144, figs. 84, plates I.]

Bulletin No. 4.—The Hessian Fly. Its Ravages, Habits, Enemies, and Means of preventing its Increase. By A. S. Packard, jr., M. D. (1880.) [pp. 43, figs. 1, plates II., maps I.]

Bulletin No. 5.—The Chinch Bug. Its History, Characters, and Habits, and the Means of destroying it or counteracting its Injuries. By Cyrus Thomas, Ph. D. (1879.) [pp. 44, figs. 10, maps I.]

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Bulletin No. 7.—Insects injurious to Forest and Shade Trees. By A. S. Packard, jr., M. D. (1881.) [pp. 275, figs. 100.]

First Annual Report for the year 1877, relating to the Rocky Mountain Locust and the best Methods of preventing its Injuries and of guarding against its Invasions, in pursuance of an Appropriation made by Congress for this purpose. With maps and illustrations. (1878.) [pp. 477+294, figs. 111, plates V, maps I.]

Second Report for the years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket, and treating of the best Means of subduing the Locust in its permanent Breeding-grounds, with a view of preventing its Migrations into the more fertile Portions of the trans-Mississippi country, in pursuance of Appropriations made by Congress for this purpose. With Maps and Illustrations. (1880.) [pp. XVIII+322+22, figs. 10, plates XVII, maps 7.]

Third Report relating to the Rocky Mountain Locust, the Western Cricket, the Army Worm, Canker Worms, and the Hessian Fly; together with Descriptions of Larvæ of injurious Forest Insects, Studies on the embryological Development of the Locust and of other Insects, and on the systematic Position of the Orthoptera in Relation to other Orders of insects. With Maps and Illustrations. (1883.) [pp. XVIII+347+91, figs. 14, plates LXIV, maps 3].

Fourth Report, being a revised Edition of Bulletin No. 3, and the Final Report on the Cotton Worm and Boll Worm. By Charles V. Riley, Ph. D. (1885.) [pp. XXXVIII+399+147, figs. 45, plates LXIV, maps 2.]

U. S. DEPARTMENT OF AGRICULTURE.

The annual reports of the Entomologist are contained in the corresponding annual reports of the Department of Agriculture. A limited author's edition, separately bound, and with table of contents and index is published each year.

Division of Entomology, Bulletin No. 1.—Reports of Experiments, chiefly with Kerosene, upon the Insects injuriously affecting the Orange Tree and the Cotton Plant, made under the Direction of the Entomologist. (1883.) [pp. 62.]

Division of Entomology, Bulletin No. 2.—Reports of Observations on the Rocky Mountain Locust and Chinch Bug, together with Extracts from the Correspondence of the Division on Miscellaneous Insects. (1883.) [pp. 36.]

Division of Entomology, Bulletin No. 3.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. With plates. (1883.) [pp. 75, plates III.]

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Bureau of Entomology, Bulletin No. 5.—Descriptions of North American Chalcididæ from the Collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological Notes. [First paper.] Together with a List of the described North American Species of the Family. By L. O. Howard, M. Sc., Assistant, Bureau of Entomology. (1885.) [pp. 47.]

Division of Entomology, Bulletin No. 6.—The imported Elm-leaf Beetle. Its Habits and Natural History, and Means of counteracting its Injuries. (1885). [pp. 18, figs. 1, plates I.]

Division of Entomology, Bulletin No. 8.—The Periodical Cicada. An Account of *Cicada septendecim* and its tredicim Race, with a Chronology of all of the broods known. By Charles V. Riley, Ph. D. (1885.) [pp. 46, figs. 8.]

Division of Entomology, Bulletin No. 9.—The Mulberry Silk-worm; being a Manual of Instructions in Silk-culture. By Charles V. Riley, M. A., Ph. D. (1886.) [pp. 65, figs. 29, plates II.]

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Division of Entomology, Bulletin No. 11.—Reports of Experiments with various Insecticide Substances, chiefly upon Insects affecting garden Crops, made under the Direction of the Entomologist. (1886.) [pp. 34.]

Division of Entomology, Bulletin No. 12.—Miscellaneous Notes on the work of the Division of Entomology for the Season of 1885; prepared by the Entomologist. (1886.) [pp. 45, plates I.]

Division of Entomology, Bulletin No. 13.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (With illustrations.) (1887.) [pp. 78, figs. 4.]

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Division of Entomology, Bulletin No. 15.—The Icerya, or Fluted Scale, otherwise known as the Cottony Cushion-scale. (Reprint of some recent Articles by the Entomologist and of a Report from the Agricultural Experiment Station, University of California.) (1887.) [pp. 40.]

Division of Entomology, Bulletin No. 16.—The Entomological Writings of Dr. Alpheus Spring Packard. By Samuel Henshaw. (1887.) [pp. 49.]

Division of Entomology, Bulletin No. 17.—The Chinch Bug: A general Summary of its History, Habits, Enemies, and of the Remedies and Preventives to be used against it. By L. O. Howard, M. S., Assistant Entomologist. (1888.) [pp. 48, figs. 10.]

Report on Cotton Insects. By J. Henry Comstock. (1879.) [pp. 511, figs. 77, plates III.]

Special Report, No. 11.—The Silkworm; being a brief Manual of Instructions for the Production of Silk. Prepared, by Direction of the Commissioner of Agriculture, by C. V. Riley, M. A., Ph. D., Entomologist. (First ed., 1879; fifth ed., 1885.) [p. 37, figs. 8.]

Special Report, No. 35.—Report on Insects injurious to Sugar Cane. Prepared, under Direction of the Commissioner of Agriculture, by J. Henry Comstock, Entomologist. (1881.) [pp. 11, figs. 3.]

Division of Entomology. Insects Affecting the Orange.—Report on the Insects affecting the Culture of the Orange and other Plants of the Citrus Family, with practical Suggestions for their Control or Extermination. By H. G. Hubbard. (1885.) [pp. x+227, figs. 95, plates XIV.]

NOTE.—During the years 1864 to 1876, inclusive, the Department of Agriculture published regularly monthly reports, mainly statistical in their character (replaced since 1876 by the series of monthly "Crop Reports"), but which contained many short articles by the Entomologist, Townend Glover. None of these articles would come within the scope of the present bulletin, and the insects treated of may be ascertained by reference to the "General Index of the Agricultural Reports of the Patent Office and of the Department of Agriculture, from 1837 to 1876." Washington, 1879.

HOW TO OBTAIN ENTOMOLOGICAL BOOKS AND PAMPHLETS.

Comparatively few of the works treating of the classification of North American insects have been published as separate books; but such as have been so published, if of comparatively recent date, can be obtained through the regular book trade. By far the greater number of the monographs and synopses mentioned in the preceding pages have been published in scientific periodicals and transactions of scientific societies. Thse periodicals and transactions can be obtained through the societies which publish them and through the publishers; but, in the case of transactions, single volumes, and more especially single papers, are seldom sold, and the older volumes are liable to be out of print. Moreover the expense attending the purchase of all of the periodicals containing the publications on a given order of insects will be so great as to put them beyond the reach of most entomologists. The custom of placing at the disposal of authors a number of separate copies of their papers overcomes this difficulty to some extent and creates a small supply. Thus it often happens that a person interested can obtain a copy of a scientific paper by addressing the author personally. Many of these separate copies also get into the possession of dealers in second-hand books, and can be purchased from them. The American Entomological Society of Philadelphia and also a few other societies here and in Europe offer for sale from their duplicates many of these authors' extras, and in some cases publish lists. There are, moreover, certain business establishments which make a specialty of the sale of works and pamphlets on Natural History, including Entomology, and it is chiefly through such establishments that the student is enabled to secure the larger portion of the works needed. In America there is at present but one of these special dealers of any prominence, viz, Dr. A. E. Foote, of 1223 Belmont avenue, Philadelphia, Pa. But in Europe there are several of considerable reputation; among these we may mention:

R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany.
Ed. André, 21 Boulevard Bretonnière, Beaune (Côte-d'Or), France.
H. W. Schmidt, Rannische Strasse, Nr. 1, Halle a. S, Germany.
J. B. Baillière et fils, 19, Rue Hautefeuille, Paris, France.
Oswald Weigel, Königsstrasse, 1, Leipzig, Germany.
U. Hoepli, Corso Vitt. Eman., 37, Milan, Italy.
Otto Harrassowitz, Querstrasse, 14, Leipzig, Germany.
William Wesley & Son, 28 Essex street, Strand, London, England.

All of these firms publish catalogues, and in writing to them the entomological catalogue should be especially asked for. There are two firms in New York which act as agents for all of these houses, and works can be ordered through them or catalogues obtained from them. These are

B. Westermann & Co., 838 Broadway, New York, and Gustav E. Stechert, 766 Broadway, New York.

By subscribing to the entomological periodicals published in this country (a matter of but slight expense) the student may keep abreast of the current literature. Short book reviews or notes published in our periodicals call attention to the more important publications in other countries. Moreover, the Zoölogischer Anzeiger, edited by Prof. J. Victor Carus, in Leipzig, Germany, and published every fortnight, gives a tolerably complete bibliography of the current entomological literature at intervals of about six or eight weeks. The "Naturæ Novitates," published every fortnight by R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany, gives the titles of most recent works and pamphlets.

There are also three great annual publications, viz: "Die Fortschritte auf dem Gebiet der Entomologie," published in Wiegmann's "Archiv für Naturgeschichte"; "The Zoölogical Record," published by the Zoological Record Society, in London, England; and the "Zoölogische Jahresberichte," published by the Zoölogical Station at Naples, Italy, which give the full literature of the previous year, discussing the more important papers and giving a list of the new species, besides other information. One or the other of these three publications is almost indispensable to the student in any branch of Zoölogy, and ought to be found in every public library in the country. Unfortunately, only a year ago the editors of the "Zoölogische Jahresberichte" found it necessary, in order to reduce expenses, to curtail the scope of the work; so that, beginning with the year 1887, this publication no longer contains titles upon systematic and classificatory Zoölogy. Only biológical titles are now published, but the series up to 1887 is the most complete thing of its kind.

A not inconsiderable portion of the North American literature on the classification of insects has been published by the General Government through various channels, and foremost among them are the Smithsonian Institution, the U. S. Department of Agriculture, the U. S. National Museum, the U. S. Geological and Geographical Survey, and the reports of the various surveys of the Territories. Many of these publications are distributed free of cost to any one applying for them; while others, like certain of the Smithsonian publications, are sold at a moderate price to cover the cost of publication. Many of them are out of print, and can only be obtained through natural history book-dealers. The firms mentioned above will have many of them, and Lowdermilk & Co., of Washington, D. C., who make a specialty of Government publications, are always able to furnish many more.

Of the more general works, some of them can be obtained direct from the publishers, and in such cases the publishers are mentioned in the general list. The older ones are mostly out of print and can only be obtained from second-hand dealers. The current State reports of Lintner and Forbes can be obtained from the secretaries of the respective State Agricultural Societies at Albany, N. Y., and Springfield, Ill., while the reports of the Entomologists of the newly established State Experiment Stations, of which a large number will soon be published, can be obtained from the directors of the respective Stations. The older reports of the State Entomologist of Missouri and the State Entomologists of Illinois (Walsh, Le Baron, and Thomas) are all out of print and can only be obtained by purchase from second-hand dealers. The same may be said of the well-known and often quoted reports of Dr. Fitch, which were published with the old volumes of the Transactions of the New York State Agricultural Society.

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U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF ENTOMOLOGY—BULLETIN NO. 37, NEW SERIES.

L. O. HOWARD, Chief of Division.

PROCEEDINGS

OF THE

FOURTEENTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, October 3, 1902.

Sir: I have the honor to transmit herewith the manuscript of the Proceedings of the Fourteenth Annual Meeting of the Association of Economic Entomologists, which was held at Pittsburg, Pa., June 27 and 28, 1902. The papers presented at these meetings are always of the highest economic importance, and the present series is of an unusually practical nature. The Department of Agriculture has hitherto published the secretary's reports as bulletins of this Division, and I therefore recommend the publication of the manuscript here presented as Bulletin No. 37 (new series).

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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FOURTEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, FRIDAY, JUNE 27, 1902.

The Association met in the west room of the Carnegie Lecture Hall, Carnegie Institute, Schenley Park, Pittsburg, Pa., at 10 a. m.. June 27, 1902.

The following were in attendance at the sessions:

E. E. Bogue, Columbus, Ohio; A. F. Burgess, Columbus, Ohio; E. P. Felt, Albany, N. Y.; G. E. Fisher, London, Ontario; W. J. Holland, Pittsburg Pa.; A. D. Hopkins, Morgantown, W. Va.; L. O. Howard, Washington, D. C.; A. H. Kirkland, Boston, Mass.; William Lochhead, Guelph, Ontario; C. L. Marlatt, Washington, D. C.; Herbert Osborn, Columbus, Ohio; A. L. Quaintance, College Park, Md.; W. E. Rumsey, Morgantown, W. Va.; E. Dwight Sanderson, Newark, Del.; W. M. Scott, Atlanta, Ga.; J. B. Smith, New Brunswick, N. J.; F. M. Webster, Urbana, Ill.

The meeting was called to order by President A. D. Hopkins, who, after calling Mr. E. P. Felt to the chair, delivered his annual address, which follows:

ON THE STUDY OF FOREST ENTOMOLOGY IN AMERICA.

By A. D. Hopkins, *Morgantown, W. Va.*

In former addresses by presidents of this Association, many different phases of the subject of economic entomology have been discussed. A review of these twelve addresses would be interesting and valuable as a reminder of the many good things presented in each. Even a list of the titles will be suggestive of the field covered, and remind those of us who had the pleasure of hearing the addresses of their striking features and the individual characteristics and special lines of thought and work of the authors:

First. The Outlook of Applied Entomology, by C. V. Riley. Champaign, Ill. 1890.

Second. Economic Entomology, by James Fletcher. Washington, D. C. 1891.

Third. Work of the year in Economic Entomology, by S. A. Forbes (first vice-president). Rochester, N. Y. 1892.

Fourth. The Drift and Balance of our Progress for the Year, by S. A. Forbes. Madison, Wis. 1893.

Fifth. A Brief Account of the Rise and Present Condition of Applied Economic Entomology, by L. O. Howard. Brooklyn, N. Y. 1894.

Sixth. Entomological Notes and Problems, by J. B. Smith. Springfield, Mass. 1895.

Seventh. The Evolution of Economic Entomology, by C. H. Fernald. Buffalo, N. Y. 1896.

Eighth. The Present and Future of Applied Entomology in America, by F. M. Webster. Detroit, Mich. 1897.

Ninth. The Duty of Economic Entomology, by H. Osborn. Boston, Mass. 1898.

Tenth. The *Laissez-faire* Philosophy Applied to the Insect Problem, by C. L. Marlatt. Columbus, Ohio. 1899.

Eleventh. Objects of the Association of Economic Entomology, by C. P. Gillette (first vice-president). New York. 1901.

Twelfth. Life History Studies on the Codling Moth, by C. P. Gillette. Denver, Colo. 1902.

For this, the thirteenth address and fourteenth meeting, the subject of Forest Entomology in America has been chosen for at least two reasons: (1) It deals with a different phase of the science, and (2) it is a subject which will be taken up as a special feature of the work of the Division of Entomology, United States Department of Agriculture, after July 1, 1902.

The primary object will be to discuss some features of the study of forest insects in America in a way which may be of service to the student and young investigator, rather than to attempt to consider the deeper problems for those of you who are already specialists in other branches of entomology.

While forest entomology has received more attention in some European countries, especially Germany, than has any other branch of the science—and forest officials there are required to have special training in the study of insect enemies and methods of combating them—it has been comparatively neglected in America. Indeed, it has only been within recent years that a sufficient need has been recognized to justify giving it special attention. Great monumental works like those of Ratzeburg of Germany, published in 1839–1844, together with the rapid advancement at that time in systematic forest management and government control of forests throughout Europe, inspired a great interest in the subject, and led to a realization of the practical importance of a knowledge of insect enemies of trees in the successful management and protection of the forests. Therefore a knowledge of forest entomology was early recognized in Germany as one of the important features in the training of forest students and forest officials. Other important contributions followed those of Ratzeburg until there is a mass of published data which is invaluable to the foresters of Europe. But these contributions, valuable as they are to the forest interests of the older countries with long established forestry systems, relate to conditions very different from those prevailing in America. Indeed, they are valuable only to the advanced student and investigator in this country, and are not valuable or specially useful to our young students, foresters, and managers of private estate. In the aggregate there has been much original and compiled matter published in the United States relating to the insects of forest and shade trees, notably by Harris, Fitch, Walsh, Riley, LeConte, LeBaron, Saunders, Lintner, Packard, and others. Within recent years considerable additional matter has been contributed by official entomologists, but up to the present time we have nothing in the line of special instructions in the study of forest entomology that is adapted to present conditions and needs in this country.

The fifth report of the United States Entomological Commission on Forest and Shade Tree Insects is the only important attempt at a general discussion of the subject. This, as stated by the author, was "designed merely to give to the public, especially those persons interested in forestry and the planting and cultivation of shade trees, a brief summary of what is known [up to January, 1888] of the habits and appearance of such insects as are injurious to the most useful kinds of trees."

This work served a most excellent purpose by bringing together in one volume the principal records of observations of forest insects by American entomologists, and has doubtless stimulated others, as it did the present writer, to an active interest in the subject of insect enemies of trees. But it would seem that there is at present a special need of an introduction or guide to the study of forest entomology for the special use of students in forest schools and others who desire general nontechnical information on the subject.

It is, therefore, my object in this address, like the pioneer making a preliminary survey in a new country, to consider the general features of the subject and leave the details to be treated in succeeding contributions as the evolution of the forestry movement in this country indicates the need.

FORESTRY AND FOREST PROBLEMS.

Forestry, which relates to the investigation of forest problems and the management of forests with a view to utilizing their products and perpetuating their resources and beneficial influences, is becoming recognized as a branch of applied science which involves some of the greater economic problems of this country.

It is made a feature of recent messages of Presidents of the United States and governors of some of the principal States. It is the subject of exhaustive Federal and State legislation. Large sums of money are annually appropriated for the establishment and maintenance of National and State forest reserves and parks, and for special research in many branches of science which have a direct bearing upon the utilization and preservation of our forest resources.

Within recent years both public and private funds have been devoted to the establishment of forest schools. Notably to the College of Forestry at Cornell University, the Forest School at Yale, and the Forest School of the Biltmore estate. Courses in forestry have been established in many of the universities and colleges, and it is even proposed to introduce the study into the common and high schools.

There is a notably increased interest in scientific investigations of forest problems manifested by the managers of some of our great railroad systems and by other companies who are extensive manufacturers and consumers of forest products. This is demonstrated by the rapidly increasing demand for special investigations and literature relating to American forests; and it indicates a general appreciation of the value of forests in their relation to public and private interests and the need of their protection.

Investigations within recent years, by the writer, in the hardwood and coniferous forests of West Virginia, the great coniferous forests of the Northwest, the pine forests of the Black Hills reserve, and the spruce woods of Maine, convince him that the depredations by insects on the living timber alone cause injuries amounting to many millions of dollars annually. A study of the insect depredations on forest products, such as railroad and other construction materials, tan bark, and minor products, makes it plain that the actual loss in money and labor amounts to many millions of dollars more each year.

Forest entomology is a branch of economic entomology which treats of insects in their relation to forests and commercial forest products, as distinguished from those which relate to farm and garden plants, and to fruit, ornamental, and shade trees.

While the determination of successful methods of protecting the ornamental and shade trees of private grounds and parks from injurious insects will depend largely upon information contributed by forest entomologists, such trees are, as a rule, grown under different conditions and subject to treatment similar to that applied to fruit trees and cultivated plants, which is not practicable in the forest. The acquiring of information by the forest entomologist involves the determination and classification of the species of forest insects, according to their systematic relations to each other, their relations to the trees they infest, and the economic results of their work; a detailed study of the life history and habits of the more important injurious and beneficial species; a special consideration of the influences and natural laws which contribute to favorable or unfavorable conditions for their life and work; and the conducting of experiments to determine practical methods of preventing losses from the ravages of the destructive species.

The information to be collected and disseminated is of two kinds: (1) That which is of a technical nature, as contributions to the advancement of science and for the special benefit of students and investigators; and (2) that which is capable of immediate practical application in the management of public and private forests and in lumbering operations.

In addition to a special knowledge of entomology, pure and applied, the student who desires to become a good forest entomologist should have a general knowledge of the science of forest zoology, forest botany, geology, chemistry, physical geography, and economics. It is also important that he have some experience or special training in practical methods of forest management, and knowledge of the manufacture and use of forest products. The universities and especially the forest schools and colleges will give the desired preliminary training in forestry, and works on general entomology, such as those by Harris, Packard, Comstock, Smith, Howard, Sanderson, and other American writers, supplemented by some of the principal foreign works, will fill the requirements for information about insects in general.

After this general knowledge is acquired, together with some training in methods of utilizing published data as guides to methods of study and to the discovery of new facts, the forest will be the school and nature the teacher which will finish the student's course and determine his right to a degree. Indeed, the student who will attain the greatest success in this, or other branches of entomology, will be the one with a natural or acquired ability and love for the work who will seek out the insects in their natural haunts and rely upon and cultivate originality in methods of observation and in collecting and recording data on which to base conclusions.

There is, perhaps, no branch of science which offers greater opportunities for the discovery of new facts and the contribution of valuable information than forest entomology. In this field very little is known compared with what there is yet to be learned. Especially is this true in regard to the life history, habits, and distribution of the injurious and beneficial species. Yet this knowledge is of the greatest importance in determining and applying methods of preventing losses.

There are, indeed, hundreds of subjects and special problems in forest entomology worthy of a lifetime study by as many specialists. There are many families, groups, and genera of insects represented by the principal enemies and friends of the forest which are sadly in need of detailed study by specialists for the accurate identification of the species and a complete revision of the literature. The insects of the pines and spruces, the cedars, oaks, and hickories, and many others of our principal forest trees, offer excellent opportunities for original investigation and the contribution of information of great importance.

METHODS OF WORK AND STUDY.

In addition to general methods of collecting. preserving, and mounting insects, as given in text-books on entomology, some suggestions may be offered for studying forest insects and for the investigation of their work.

First of all, the student should keep in mind that there are many collectors of insects and many students in general entomology, as well as numerous specialists who are collecting and studying insects of all orders found in the forest and field. Thus he should avoid general collecting, and devote his time to the accumulation of specimens and observation on life histories and habits of insects which are associated with injuries to forest trees or forest products.

In addition to a general study of insects which have some economic relations to forests, he should select, at as early a date as possible, some special subject for detailed study. There is no lack of important subjects, as has already been suggested, but in making the selection the prevailing conditions, opportunities, and facilities in the immediate vicinity or sections in which the studies are to be conducted should be considered. If it is in a pine region, insects affecting pines will offer the most desirable opportunities for study; if in a hardwood region, those affecting the oaks, hickories, chestnut, and the like will offer the best opportunities. If there is some prevailing injury to a given kind or class of forest trees, this will at once suggest itself as the most important to take up. It matters not whether it is the study of the insect fauna of a species or genus of forest trees, the causes of a special class of injuries, or the study of a single family, genus, or species of insect. There is enough in each case to keep the student occupied in original researches for many years, and to furnish sufficient material for contributions to the literature of the subject. Indeed, every student who takes up forest entomology as a life work should start out with the object of acquiring and disseminating as much knowledge as possible on some special feature of the science. To thus become a specialist of this kind does not necessarily imply that he will have a narrow comprehension of the entire subject. Even if one were to try to find out all that is to be known about a single enemy of a forest tree, and every possible method of preventing losses from its work, his work would involve a general knowledge not only of forest entomology in its broadest sense, but of all related sciences and subjects. In fact, as a great thinker has said, in order to know all about any one thing it is necessary to know all about everything. While this may not be literally true, it is becoming recognized that there is almost an unlimited interrelation of all sciences and all subjects.

COLLECTING SPECIMENS AND RECORDING OPERATIONS.

The equipment for collecting specimens need not be expensive or elaborate. The necessaries are: A hatchet or light ax, carried in a scabbard, which may be fastened to a stout belt; a hunting coat, or an ordinary sack coat, with many pockets; a supply of collecting vials of various sizes, fitted with the best cork stoppers; a small bottle of alcohol; a medium and a small cyanide bottle; tweezers; camel's hair brushes; a stout knife with small and large blades; a small saw; a net and umbrella; and last, but not least important, a notebook and pencil. With this equipment, or such part of it as is required for the special kinds of specimens desired, a good observer can go out in the woods any day in the year and find plenty of material.

The best places to collect species infesting wood and bark is along the edge of the woods, or where trees have been girdled or felled a few months previous. Here one will usually find in the bark of the roots, stumps, main stems, tops, branches, and twigs different stages of many species of bark-beetles and bark-inhabiting larvæ, together with their natural enemies and associates; and the wood will yield many more.

Lumbering regions and sawmill yards are especially prolific in specimens at all times, as are also broken branches, individual trees, and groups injured or killed by insects, felled by storm, or otherwise rendered attractive to insects. During the spring, summer, and fall the foliage will yield specimens almost unlimited in number and variety. But one should remember, as has already been indicated, that it is not the number and variety, but those of most importance, that are to be sought out, noted, collected, and studied. It is often better to spend a day in the diligent search for all that can be found in or on a single tree, or in observing and recording in the notebook all that can be found out about a single species, than merely to collect hundreds of specimens or many species without careful records.

Indeed, the proper recording of what one sees at the time the observations are made is of the greatest importance, and is the one thing the student should practice more, perhaps, than anything else.

RECORDING OBSERVATIONS.

While nearly every entomologist has adopted some system of taking and keeping notes on observations in the field or laboratory which is specially adapted to his own line or method of study, and shows marked peculiarities, there are certain general principles and rules which should be laid down for the consideration and guidance of the student and amateur investigator.

In collecting specimens and in field observations the notes taken should include the following: The exact locality (the nearest post-office, hill, mountain, or farm); when possible, the elevation and the exposure; the date; the host plant; point of attack; what stages occurred, etc. If it is associated with any special injury or trouble affecting the plant or object from which it obtains its food, the fact should be noted. As many details as possible should be briefly or fully noted. Every separate note referring to collected material should be numbered. In regard to the use of numbers, it should be specially remembered that the numbered specimens serve as an index to the notes relating to them. Therefore the same numbers should never be used a second time. The student should start out with the idea of using consecutive numbers as long as he collects insects. At the same time economy should be practiced in the use of numbers, and this can be accomplished in many ways; as, for instance, No. 1 may be made to refer to more than 100 different entries relating to insects collected on the same date and from the same tree. It may be used 26 times with a letter of the alphabet preceding it (as a1, b1, etc.), 26 times more with letters following it (as 1a), 26 times more with a letter over it, and indefinitely with decimals or fractions. The object in view is to adapt the numbers to all requirements without the necessity of repeating or having them attain inconvenient proportions.

If the object in view is simply to get the specimens, then the locality and date, with the collector's name, are all that is necessary to accompany the specimens in the bottle or on the pin. If the student has ambitions, however, to accumulate material and data which will be of the greatest value, he will give special attention to the accumulation of material which represents more than localities and dates. Our museums and private collections are already oversupplied with this kind of material, which is well enough as far as it goes; but the student who would be satisfied to go no further than this had better not enter the field of forest entomology. His place would be in the museum with dead specimens—a place, by the way, where a vast amount of good and indispensable work is done in systematic study and identification of specimens; but this is in the line of pure science, while the forest entomologist's ambition should be to contribute to the advancement of both pure and applied science. He can do this best by recording as many facts as possible about the specimens he collects and observes.

After the student has progressed far enough to be able to accurately identify the principal species as they are observed in the field, very many observations may be recorded without collecting specimens or the use of numbered notes. But this should not be attempted until after years of practical work, and even then it can not be reliable except with such species as are perfectly well known. Observations and records based on field identifications by some of our best entomologists have led to much confusion in literature about some of our common insects. This has been abundantly demonstrated by the writer in a recent study of the types of Scolytidæ, described by one of the best American authorities on the Coleoptera of North America. There are a number of examples where a common enemy of forest trees has been identified from descriptions or from observation in the field as a certain species, and after a great deal has been published under the erroneous names it has been found upon comparison with the types that it was quite a different thing, with different habits from the species to which the name properly belonged; and in some cases what was supposed to represent a well-known species was even found to be undescribed. It will, therefore, be readily seen how important it is for the species we write about to be accurately identified, and how necessary to have a numbered specimen to refer to for future corrections or to send to a specialist for authentic identification.

It is always of the greatest importance to observe the character of the work of the insects when found in their natural feeding or breeding places; and, whenever possible, specimens of the work should be secured for the collection, especially the work of wood and bark boring species and that showing special or characteristic injuries to the foliage, etc.; and each should, as with the insect specimens, be accompanied by the note number.

It is also important for the beginner to collect large numbers of specimens both of the insect and its work whenever the opportunity offers. For, even if there should be more than he needs for his own collection, they may be specially valuable for exchange with other collectors for desirable material from other localities and countries. One of the commonest mistakes made by most young collectors, and, for that matter, many older ones, is the failure to avail themselves of the very first opportunity to collect an abundance of material relating to any desirable species. It must be remembered that because an insect is common at one time or place it does not always follow that it will continue to be so or that it is common in other places. Indeed, the reverse is the rule. A period of great abundance is usually followed by a period of great rarity, or, as has sometimes happened, almost complete extinction.

The collector should be constantly on the lookout for the natural enemies of the principal injurious species. One class of the enemies of insects consists of parasitic Hymenoptera, Diptera, etc., found in the adult larval or pupal stage, associated with their host, the larvæ as external or internal feeders on the larvæ, pupæ, or adults of the injurious species, and the adult parasites ovipositing on or in the victims, or in the bark or other infested parts of the plant. The other class of insect enemies of insects are predatory species of Coleoptera, Hemiptera, Hymenoptera, and other kinds of insects which attack and kill their victims, and either devour them or suck out the liquid parts of their bodies. There are also insect diseases which may be indicated by a white powdery substance on the bodies of the dead insects, and, whenever numbers of examples are found to be dead or dying, specimens should be collected and submitted without delay to some specialist on this class of diseases.

METHODS OF COLLECTING AND REARING LIVING MATERIAL.

It is always desirable to collect living material to rear or breed for the purpose of securing data on life histories and habits. This will consist of eggs, larvæ, and pupæ of foliage-infesting insects to be reared in breeding cages; also bark, wood, branches, and twigs infested with immature stages, to be reared to adults in breeding jars, boxes, or cages.

Specimens from the foliage should be collected in small tin boxes, together with a small amount of their natural food. Some of the smaller things may be reared in the boxes in which they are first collected, if supplied from time to time with fresh food material, while others must be transferred to breeding cages or larger tin boxes. Living specimens in wood or bark are easily collected in sections cut from the infested parts of the plant, and carried in the larger pockets of the hunting coat; or, if a long distance from the laboratory, they may be packed in bundles or boxes and shipped by the most convenient method available.

For breeding specimens from this kind of material, the writer has secured excellent results by the use of different-sized fruit jars with clamp covers. The screw-topped jars are also very convenient for this purpose. For very large sections, or a large amount of material of one kind, tight barrels or large wood or galvanized-iron boxes may be used to advantage.

For carrying on the more elaborate work of rearing from wood and bark, a specially constructed insectary is necessary. Wood and bark infesting larvæ and pupæ, and parasitic larvæ in cocoons, may be successfully reared to adults in bottles or vials which are just large enough to accommodate single specimens. These small vials with cork or cotton stoppers are indeed specially convenient for the rearing of parasitic larvæ and pupæ taken from the mines or pupa cases of the wood or bark-inhabiting host.

PRESERVING, MOUNTING, AND LABELING SPECIMENS.

The specimens that are killed in 25 per cent alcohol should be removed from the bottles in a day or two after they are collected, then cleaned thoroughly and replaced in clear 80 or 90 per cent alcohol. The specimens killed in the cyanide bottle should be gone over, separated, and either mounted or stored where they will be free from museum pests.

The specimens of work of insects should have the surplus parts removed, and should be labeled and stored where they will be readily accessible for future reference. Broad shallow drawers or trays are convenient for the smaller wood and bark specimens, while wood or heavy paper boxes serve for larger ones. Common florists' paper boxes, which are shipped flat ready to be made up, are excellent for storing the classified material.

Every individual specimen should have the number of the note referring to it, or the series to which it belongs, and also something to designate the particular set of notes or accessions catalogue to which the number refers, as "500, Hopk., W. Va.," which means entry No. 500 in the accessions catalogue of the entomological department of the West Virginia Agricultural Experiment Station, Morgantown, W. Va., A. D. Hopkins, collector. As long as the specimens remain in the collection with the catalogue these accession numbers are all that is necessary for the duplicate material, since they serve at once as index to the readily accessible notes. If, however, any of the specimens are transferred to other collections they should always bear labels showing date, host, and such other facts as are of primary importance to preserve their identity, or if a large number of examples of different species are sent a list of species and accessions catalogue numbers with extracts from original notes should accompany them, together with the address of the individual or institution having permanent charge of the accessions catalogue.

The specimens of the work of insects may have the number and other data written on them, or on paper labels and pasted on or otherwise attached. If the specimens are fastened on cardboard or to the bottom of the case, labels may be printed and pasted beneath them.

WHAT TO STUDY.

After the student has acquired some knowledge of how to study, collect, and make proper records of observations, and how to label and preserve specimens, it is important for him to consider well what there is of importance to study and investigate, and how to get results of practical value. Forest entomology embraces only such insects as are in some way related to human interest in forests and forest products. Therefore, the student must confine his studies to the insect fauna of the forest growth which is of some economic importance, with the view to determining which kinds are injurious, which are beneficial, and which are neutral in their relation to the life history of the plant and the future usefulness of its products.

Commencing with the matured seed or fruit of trees, such as the oaks, hickories, walnut, and others, we find that not only the nut or seed, but its envelope (hull or pod), is the home of many kinds of insects. On the tree, fallen, stored for use, or planted in the ground, they support some different kinds of insect enemies or guests, as they do, also, from the time the seed bursts open and the roots and stem begin to form through all stages of the seedling, the sapling, the young, matured, old, dying, dead, and decaying tree. Not only does the tree, during each stage in its life history, death, and decay, support some kind or kinds of insects peculiar to each, but every part—the rootlets, the larger branching roots, the main roots, the lower stem, the upper stem, the large and small branches, the twigs, the buds, the young leaves, the flower buds, the different parts of the flower, and the embryo fruit—will have its special guests. Some kinds inhabit the outer bark; others, the intermediate or inner bark, the cambium, the outer or inner sapwood, the heartwood, or the pith.

Not only during its life, but from the time it dies until it is entirely decayed and converted into humus, a tree supports many and varied forms of insect life. Some are its enemies, some its friends; others, neither enemies nor friends, but guests and scavengers. Among its enemies some have special designs upon its life in order that its dying may furnish favorable conditions for the rapid increase of the insect progeny, and consequent increased power in numbers to attack and kill other trees. Some are enemies only to the extent of causing injuries to the roots, bark, wood, branches, and foliage which may be detrimental to its perfect development or its future usefulness to man, but have little or no immediate effect upon its vitality. Others are enemies only so far as they obtain their food from some living part, yet do no permanent injury, such as certain kinds of leaf-eating, sap-sucking, and gall-making insects, which are never or rarely common enough for special harm. There are many other kinds which obtain their food directly from the dead parts of the living tree, such as the outer bark, dead twigs and branches, dead wood, etc., which can scarcely be considered as enemies of the living tree. Among the friends of the living tree are the insects which feed upon the injurious kinds, either as internal or external parasites, or those which attack and devour their prey. Among the guests of the injurious and beneficial inhabitants of the tree there are many kinds which live in the burrows and feed upon the sap, borings, excrements, dead insects, etc., while there are many other kinds which utilize some part of the tree or the burrows of other insects as hiding or hibernating places.

THE INSECT FAUNA OF FOREST PRODUCTS.

The natural products, such as nuts, medicinal roots, bark, and leaves, tan bark, etc., each, under certain conditions of storage and age, furnishes feeding and breeding places for many kinds of injurious, beneficial, and neutral species. The manufactured or commercial wooden products of all kinds, the crude round or square timbers, lumber, staves, hoop poles, etc., are, under certain conditions, subject to attack or serious injury from various kinds of insects while in the woods or when stored in yards and factories. The seasoned and finished products, especially those from sapwood, may be infested and destroyed by a number of species of so-called powder-post beetles. Construction timbers and lumber, either before being utilized or while in the structure, are subject to injuries by many injurious and other species. The old lumber and timbers of barns and outbuildings, old log and frame dwelling houses, are also infested and injured by forms which are peculiar to such material.

THE ECONOMIC RELATION OF INSECTS TO FORESTS.

The preceding references to the insect fauna of forest trees and their products are suggestive of the vast numbers of kinds, groups, and societies of insects and the kind and character of injuries to be studied. This leads us to a consideration of the economic relation of insects to American forests under the varying conditions which prevail before and after the country is settled and its resources developed.

The relation of injurious insects to the primitive forests.—The relation of insect enemies of a forest before its resources are available to civilized man is of little or no economic importance. They are simply factors in the general struggle for existence between insects and trees, and between the individuals of the forest community in which the destruction of an individual tree by insects is a benefit to other insects and other trees. If a matured or old tree is killed, it gives more room for the development of the younger and more vigorous ones. The injured, declining, and old individuals furnish breeding places for successive communities of insects, which contribute to their death and rapid decay. Thus the young tree growth is favored by light and plant food, and soon fills up the vacancy. Invasions of destructive insects may cause the death of one kind of tree growth over vast areas. This favors the enormous multiplication of the insect fauna until the destructive species perishes for lack of food supply, or from the multiplication of its natural enemies. This proves to be a calamity to the other insects which have depended upon the destructive species to furnish, in the dying and dead trees, the required conditions for their existence. The dying and dead trees and the fallen and decayed branches, bark, and roots contribute to a more vigorous reproduction, so that the forest found by the pioneer settler has lost nothing from its insect enemies.

The relation of the insect enemies of trees to the pioneer settler in a forested country may be more beneficial than otherwise, so far as his immediate needs are concerned. The forest must be cleared from the land that is desirable for agricultural purposes, and in this process the depredating insects may be decidedly beneficial. They contribute to the death and rapid decay of the girdled trees in the clearings and hackings. Invasions which cause the death of the large timber over great areas may be utilized to the especial advantage of the agriculturist, and contribute to the prosperity of the community of settlers. The dead trees, with the fallen tops, furnish the most favorable conditions for the process of clearing by fire. It saves the expense of girdling. Often the flint and tinder or the torch was all that was necessary to start a conflagration which effectually cleared the land of dead and felled timber, and killed the remaining living trees and young growth.

The relation of insect enemies to the forest of a settled country.—The great destruction and waste of the best of the forest resources necessary to the progress of civilization finally reaches a stage at which the forest is more valuable for its commercial products of timber, its protection of springs and head-water streams, than is the land for agricultural products. Thus as time progresses the insects become more and more injurious in their relation to the public interests. The destruction of matured timber by insects comes to be recognized as a serious loss. Their burrows in the wood of living and dead standing timber and that felled for saw logs and other purposes are recognized as serious defects which reduce the profits of the manufacturer and increase the prices of the clear product to the consumer. The injuries to the young growth which result in the development of a deformed, worthless tree become an element of future financial loss. The areas of dead timber killed by insects become a menace to the forest, furnishing as they do favorable conditions for the outbreak of destructive forest fires and the development and spread of wood-boring insects.

While the more destructive kinds of bark-boring insects may aid in the death of girdled trees, such trees at the same time furnish favorable conditions for the rapid multiplication of the insects and thus contribute to destructive depredations on the valuable living timber in the adjacent forests.

As the merchantable timber and the manufactures of wood become scarcer and the price to the consumer increases, the depredations which a few years before would have remained unnoticed attract more and more attention, and the need of methods of preventing losses from this source is fully realized. Then requests are made for information relating to the kinds of insects that cause the troubles and the details in their habits which is necessary in order to successfully combat them.

Their relation to the public and private forests and farmers' wood lots.—The relation of injurious insects to forests which are under systematic management present quite a different problem from those relating to more primitive conditions. In dealing with the latter there is little opportunity for the practical application of a knowledge of forest entomology, but the former present economic problems worthy of special study and investigation. All of the injurious species may be considered in this relation as enemies, not only to the forests but to public interests. The introduction of forestry methods offers opportunities for the adoption of methods of preventing much of the losses which under previous conditions could not be avoided. It also offers opportunities for extended research and experiments for the determination of the more important facts relating to the habits and life histories of the insects and their depredations, which will lead to the discovery of improved methods of control.

THE KINDS AND CHARACTER OF THE WORK OF INSECT ENEMIES OF THE FOREST.

The fruits of forest trees are injured by the adults and larvæ of species which feed upon the pulp, pod, or other covering, and thus destroy the seed or prevent its normal development. The seeds are injured or destroyed by beetles and their larvæ, by the larvæ of moths, and by gall-making insects. Nuts of all kinds and the hard fruit of many trees are infested by larvæ from eggs deposited in the growing fruit by small beetles. The entrance of the young larva through the young, tender hull or outer shell heals over so that the ripe nut shows no trace of it. The larva feeds on and destroys the germ and kernel and, when fully grown, bores its way out and enters the ground, where it goes through the transformations and emerges as an adult next year in time to deposit its eggs in the young nuts. Thus the seeds of some trees may be so completely destroyed that few remain for reproduction. This may cause considerable expense and loss to the forester, both in adding to the expense of collecting a sufficient quantity of sound seeds and in causing an uneven stand in the nursery on account of the damage to the stored and planted seeds. This class of injuries also causes a serious loss of the commercial product of chestnuts, hazelnuts, hickory nuts, etc.

The seedling in the forest or in the nursery row is attacked and injured by many kinds of insects. The roots are eaten by the larvæ of beetles and the sap sucked out or poisoned by root-lice. The stem is attacked by wood and bark-boring beetles and grubs. The foliage is devoured by caterpillars, larvæ of sawflies, and grasshoppers, or injured by plant-lice, scale insects, leaf-hoppers, and leaf-bugs. The twigs are injured by twig girdlers, twig miners, scale insects, and plant-lice. As a result, the seedling may either be killed or become stunted or deformed.

The young tree is in a like manner attacked and injured or killed by one or more enemies of the roots, stem, or top. The principal injuries, however, which are characteristic of the growing tree, are those made in the roots and base of the stem by the great root borer, and in the wood of the main stem by the carpenter worms and other borers, which are capable of working in the wood of living healthy trees. While this class of enemies may have little or no direct effect upon the vitality of the trees infested by them, they cause a great loss of commercial products. Their burrows cause defects in the wood, and are the means of starting decay, which renders the heartwood worthless for commercial purposes. The living bark may be attacked by bark-boring grubs in sufficient numbers to seriously affect its vitality, so that it will soon succumb to the attacks of other insects or diseases.

The mature tree suffers most from the many wood-boring beetles and grubs. The destruction of some of the larger roots by the great root borer causes dead branches and dead tops. The borings of the carpenter worm and other borers in the main trunk, top, and larger branches result in rapid decay, hollow trunk, and generally worthless condition, while its weakened vitality makes the tree an easy prey to destructive bark-boring enemies. The trees blown down by storm or felled by the ax are attacked by a vast number of species of insects. Some live in the bark, where they do little or no harm to the commercial product, but certain kinds may thus multiply rapidly and attack the standing timber. The wood, however, may be seriously injured by many species of wood-boring beetles and grubs which breed only in the wood of dead and felled trees.

Old dead, standing, and felled trees and old logs and stumps are infested by many insects which not only contribute to the rapid destruction of the wood, which otherwise might have some commercial value, but certain kinds breed in such material and emerge to attack the wood of recently felled trees and injured places in the standing living ones. They also attack square timbers in bridges, trestles, railroad bed, etc.

SOME OF THE PRINCIPAL INSECT DEPREDATIONS IN THE FORESTS OF THE UNITED STATES.

THE PINES.

Between 400 and 500 species of insects are known to inhabit the living, dying, and dead pines of the United States. The pine forests of the East, Northeast, and Southeast have suffered and are now suffering greatly from the ravages of destructive bark-beetles. A few years ago (1890–1892) a trouble spread over an area of 75,000 square miles in the Middle Appalachian region which resulted in the death of millions of pine trees. This included all of the indigenous and some of the introduced species in the forests, private grounds, and parks. Upon careful investigation, this trouble was found to be caused primarily by the ravages of a single species of bark beetle (*Dendroctonus frontalis* Zimm. var. *destructor* Hopk.). Previous to 1890 this was a rare insect in collections, and nothing was known of its habits. It disappeared and the trouble ceased in 1893. This insect is liable to appear again in destructive numbers. It is therefore of the greatest importance that special efforts be made to determine the sections in the Eastern and Southern pine forests where it may yet survive, so that measures may be taken, by introducing or encouraging its natural enemies or by girdled trap trees, to prevent its multiplication and future destructive invasions.

Recent investigations in California, Oregon, Washington, and Idaho, by the writer, under the auspices of the Division of Entomology, United States Department of Agriculture,[a] revealed the fact that the western yellow pine, Jeffery pine, sugar pine, mountain or silver pine, shore pine, and lodgepole pine has each its peculiar insect enemies, some of which are very destructive. Many of the finest examples of yellow pine were found to be dead or dying from the ravages of the western pine destroyer (*Dendroctonus brevicomis* Lec.) from northern California to northern and western Idaho. The mountain pine in northern Idaho and western Montana suffered severely from the ravages of the mountain pine destroyer (*Dendroctonus monticola* Hopk. MSS.). The yellow pine has also suffered greatly in Idaho and eastern Washington from the larvæ of a white butterfly (*Neophasia menapia* Feld.), which defoliates the trees over large areas.

Recent (September, 1901) investigations in the Black Hills forest reservation revealed the fact that a vast amount of the best timber on many thousands of acres has died within the past six or seven years and is yet dying from the ravages of the pine-destroying beetle of the Black Hills (*Dendroctonus ponderosæ* Hopk. MSS.).

It is also reported that the pine is dying in other sections of the Rocky Mountain region, from Idaho to Arizona, evidently because of the ravages of bark beetles.

It is evident from observations made in the Black Hills reservation and in the forests of Idaho, Washington, and Oregon that the death of the pine timber over many extensive areas, supposed to have resulted from fires, was primarily due to the work of tree-destroying insects. Even the meager knowledge we have been able to acquire during hurried investigations in the forest and from observations along the routes of travel through the Rocky Mountain region, the Pacific slope, and the Northwest makes it very plain that the destruction of pine timber, due primarily to the ravages of insects, has been progressing during the past half century at a rate far beyond that conceived by the casual observer or even by those who are making a study of the forests and forest conditions of those regions. Indeed, the extensive ravages of insects on the pines of the United States furnish a problem whose great importance and magnitude would justify the expenditure of large sums of money for detailed investigation by specially trained forest entomologists.

THE SPRUCES.

The spruces of this country are also inhabited by many hundreds of species of insects.

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[a] Bul. No. 21 (n. s.), Division of Entomology, U. S. Department of Agriculture.

The Red Spruce of the middle and northern Appalachians, from West Virginia to northern New York and on through northern New England to Canada and New Brunswick, has, from time to time during the past century, suffered severely from troubles, some of which are known, and others believed to be, caused by bark-beetles.[a]

A large amount of spruce was killed in West Virginia about 1885, evidently by a bark-beetle, but the trouble was not investigated until 1890, so the exact species deserving the blame could not be determined.

In 1892 the destructive pine bark-beetle spread in West Virginia from the pine into the spruce, and caused the death of a large amount of the best timber.

The great destruction of spruce, which has attracted so much attention from New York to New Brunswick, was found, upon special investigation, to be largely if not entirely due to the primary attack of the spruce-destroying beetle (*Dendroctonus piceaperda* Hopk. MSS.).[b]

The Sitka Spruce of the Northwest has numerous enemies, among which the Sitka spruce Dendroctonus (*Dendroctonus obesus* Mann.) is the principal depredator in the bark of living and declining trees, while the spruce-destroying spanworm (*Philedia punctomacularia* Hulst.?) may be considered as the greatest insect destroyer of forests of this tree and the Western Hemlock.[c] Scarcely anything is known about the life history and habits of this insect. Therefore it presents a problem of special importance for investigation.

The Engelmann Spruce has a number of insect enemies, one or two of which are capable of causing wholesale destruction.

Vast quantities of dead spruce occur in different sections of the Rocky Mountain region which, it would seem, bear no trace of having been killed by fire, and the cause will probably be found to be the attacks of some destructive bark-beetle or defoliating insect.

THE HEMLOCKS.

The Eastern Hemlock has a serious enemy in the hemlock destroyer (*Melanophila fulvoguttata*), which has caused the death of a large amount of hemlock timber throughout the Appalachian and Northeastern regions.

The Western Hemlock has at least three destructive enemies of the living trees: (1) The Western hemlock bark-borer (*Melanophila drummondi*), which is closely allied to the Eastern species, and like it extends its burrows beneath the bark and either kills the trees or causes serious gum-spot defects in the wood; (2) the Douglas spruce bark-borer (*Asemum nitidum*), which has similar habits to those of the hemlock bark-borer; and (3) the Sitka spruce spanworm, which defoliates and kills the trees over large areas.

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[a] Buls. 17 and 56, W. Va. Agr. Expt. Station, and Bul. 28 (n. s.), Div. Entom. U. S. Dept. Agr.

[b] Bul. 28 (n. s.), Div. Ent., U. S. Dept. Agr.

[c] Bul. 21 (n. s.), Div. Ent., U. S. Dept. Agr., 1899, p. 18.

THE CEDARS.

The California Redwood has a special enemy in the sequoia bark-beetle (*Phlœosinus sequoiæ* Hopk. MSS.)

The Giant Arborvitæ has an enemy in *Callidium janthinum*, and the Eastern Arborvitae one in *Hylotrupes ligneus*, which infest the living trees and either kill them or cause serious defects in the wood. The other true cedars, the Monterey Cypress, and some of the Western and Eastern junipers, have a number of bark- and wood-boring enemies, which are more or less destructive.

THE FIRS.

The Western, grand, noble white, and Shasta firs, and the Eastern balsam firs are attacked by several destructive bark-beetle enemies, which either kill the trees or cause serious gum-spot defects or decayed places in the wood.

THE OAKS.

The insect fauna of the oaks is very large, probably exceeding in number of species that of the pines. Those noted for their especially destructive attacks on living trees are the carpenter worms (*Prionoxystus* spp.), which bore into the bark and wood and not only cause serious worm-hole defects, but by successive attacks cause the death of part or all of the tree. Their burrows give entrance to wood-decaying fungi which soon render the heartwood worthless for commercial purposes. The giant root-borer (*Prionus laticollis*) is another enemy of Eastern oaks in general, which is enormously destructive to large and small trees in forest, park, and lawn; but it would seem that its work is rarely recognized, and that the magnitude of the damage is not generally understood. The large, white, elongate grubs bore in the roots and bases of the trees, causing one or more of the larger roots to die. These holes and the burrows made by the carpenter worms give entrance to other wood-boring insects and wood-destroying fungi, which rapidly extend and complete the destruction of the injured parts. This decay often extends into the base of the trunk, destroying the heartwood and thus causing the tree to be hollow and worthless. The decayed wood of the roots and base of the tree also furnishes fuel for forest fires, so that the trouble started by the giant borer, and extended by other insects and fungi, is made conspicuous by a great blackened wound, which is more often than otherwise supposed to be due to fire alone. Trees are often killed outright by this root destroyer, but the work is usually so obscure that the trouble is often blamed to other bark and wood-boring insects, which attack the tree as soon as it manifests weakened vitality.

The two-lined chestnut borer (*Agrilus bilineatus*) is another enemy of medium to large white oak and other oak and chestnut trees, which has caused the death of a large amount of this kind of timber throughout the Appalachian region.

The oak timber worm (*Eupsalis minuta*) is one of the most destructive enemies of the wood of living, dying, dead, standing, and felled trees. It causes what is known as pin-hole defects. The loss of the more valuable timber of the largest and best trees caused by this insect is enormous; indeed it is far beyond the conception of persons who have not given special attention to the subject. The ravages of this insect do not end with living and dead trees, but it continues its work in lumber and square timber from infested logs, and will even attack freshly sawed and closely piled oak lumber. This insect alone furnishes one of the big problems for detailed investigation.

The Columbian timber beetle (*Corthylus columbianus* Hopk.) causes one of the commonest defects in white oak lumber and square timber. It attacks and breeds in the sapwood of living trees, and the healed-over wounds cause pin-hole and stained-streak defects.

A serious trouble has for many years affected the oaks of the northern United States from New York to Minnesota, and has caused the death of a vast amount of timber in lawns, parks, and the forest. This has not been specially investigated, and therefore little or nothing is known regarding the primary cause.

THE CHESTNUT.

The living chestnut trees throughout the Appalachian region, and apparently wherever this tree grows, have a most destructive enemy in the chestnut timber worm (*Lymexylon sericeum*). This wood-boring worm or grub hatches from eggs deposited in the slightest wound in the bark and surface of the wood, and burrows deep into the heartwood, causing the wood of nearly every old tree to be perforated with pin-hole defects. It attacks and breeds in dying, dead, and felled trees and stumps, and will continue to work for a time in square timber, telegraph poles, and heavy timber cut from infested trees. It also infests red oak, and often renders worthless parts of the trees which otherwise would make the highest grade timber. The enormous damage to the forest resources of the United States caused by this insect makes it one of primary importance to take up for detailed study and for exhaustive experiments with different methods of reducing the numbers of the pest and preventing losses from its ravages. The giant root-borer and the two-lined chestnut borer also attack chestnut, and in some sections do great harm.

THE HICKORIES.

The hickories of lawns, parks, and forest have suffered from time to time within the past half century from the destructive ravages of the hickory bark-beetle (*Scolytus 4-spinosus*) from Missouri to northern New York and West Virginia. Recent investigations and extensive experiments with felled and girdled trees indicate that this pest can be controlled so that under a system of improved forestry management little or no loss should result from its attack.

The poplar, tulip, beech, birch, and, in fact, all of the principal forest trees have their special insect enemies, which attack the living trees and are more or less destructive to their lives or to the commercial value of their timber products.

DEPREDATIONS IN THE WOOD OF DYING, DEAD, AND FELLED TREES, TIMBER PRODUCTS, CONSTRUCTION TIMBER, AND STORED PRODUCTS.

In addition to the primarily destructive enemies of living forest trees, there is a host of enemies of the wood of the dying and dead standing and felled trees of all species, which cause serious defects and rapid deterioration. Many of these injuries to the wood present problems of great economic importance and most promising lines of investigation in the possibilities of discovering simple methods of preventing losses.

Construction timbers.—There are a number of wood-boring insects which attack and breed in heavy construction timbers, especially those used for railroad ties and in culverts, trestles, and bridges. These are not only weakened by the borings of the insects, but entrance is given to wood-decaying fungi, which work so rapidly that, before it is realized, certain parts may be rendered exceedingly dangerous. Therefore, the relation of the combined effects of insects and fungi to accidents from the collapse of buildings and railroad structures is a subject of special interest and importance for detailed study.

Stored forest products.—Insect depredations on stored forest products, such as tan bark, hickory handles, buggy spokes, and hoop poles, is another problem coming within the range of forest entomology which demands special attention. Recent investigations of insect enemies of stored tan bark have revealed the fact that both oak and hemlock bark are subject to attack by at least five species of insects, which convert into fine powder the inner or flesh part of the bark that has been stored over two or three years. As much as $70,000 worth of hemlock bark was found to be infested at a single tannery in West Virginia, and personal investigations at other tanneries in the State, together with information from other States, indicate that this is a widespread trouble in the East and North and evidently extends into Canada.

The destruction of stored hickory, oak, maple, and other hardwood lumber, and the various products manufactured from hard woods, due to the ravages of powder-post beetles (*Lyctus* spp.), is a widespread trouble in this and other countries, and has caused the loss of a vast amount of valuable material. Yet comparatively little has been done in this country toward a detailed study of the problem and the elaborate experiments necessary to determine methods of preventing attack.

THE INTERRELATIONS OF INSECTS, FUNGI, AND FIRES IN THE DESTRUCTION OF FORESTS.

This is another problem that recent investigations have demonstrated is one of very great importance. Heretofore it has been almost entirely overlooked, and much of the destruction which has been going on in all of the great forest areas of the country that is primarily due to insect attack, and secondarily to fungi, has been attributed to forest fires, which really occupied third place among the destructive factors.

The examples of destructive insect ravages mentioned here are only a few of a long list that could be given. They should be sufficient, however, to indicate the number and the magnitude of the problems in forest entomology, which, on account of their special economic importance, should be thoroughly investigated.

The need of exhaustive study of these problems is all the more apparent when it is realized that comparatively nothing is known of the more important facts relating to the life history and habits of some of the principal depredators, the conditions that contribute to sudden and destructive invasions, or those that bring about an equally sudden ending of a serious trouble. Without this knowledge little or nothing can be done toward the recommendation of effectual methods of preventing losses. Enough has been determined from a detailed study of some of these problems to indicate quite clearly that a better knowledge of some of the fundamental facts will lead to the adoption of simple, inexpensive methods by which the loss of a vast amount of timber and timber products may be easily prevented.

REMEDIES AND OTHER METHODS OF PREVENTING LOSSES.

The problem of controlling insect enemies of forests is quite a different one from that relating to the control of farm, garden, and fruit and shade tree insects. Indeed, they must be considered from a different standpoint—that of prevention rather than that of destruction. Thus every separate trouble caused by different insects or the troubles caused by the same kinds of insects in different sections of the country must be studied separately with a view to determining methods of utilizing some method of management specially adapted to the prevailing conditions in each case, which will reduce the number of the depredators or otherwise prevent losses.

SOME PRACTICAL RESULTS.

A few examples may be given of the practical application of a knowledge of some of the principal facts in the life history, as follows:

The recent determination that the tanbark-destroying insects do not attack the stored bark until it is two or three years old suggested a simple method of preventing losses.

The determination that the spruce-destroying beetle attacks only the larger trees, and that the beetles could be attracted to trees hack-girdled during the proper period in June, suggested important methods of forest management and lumbering operations, which will contribute to the elimination of trouble from this pest.

Girdling and timber-cutting experiments have demonstrated the possiblility of preventing losses from the ravages of insects and wood-destroying fungi by girdling and cutting timber when the physiological conditions are such as to render the bark and wood unattractive to the depredators or unfavorable for their destructive work.

A knowledge of the habits and characteristic work of bark-infesting insects in living, dying, and dead trees furnished conclusive evidence that a large amount of healthy, uninfested, living timber had been cut in the Black Hills forest reserve, where it was intended that none but trees infested by the pine-destroying beetle or those killed by it or other causes should be cut. It was also demonstrated that a knowledge of the principal facts relating to the primary and secondary insect enemies of the pine of this region would facilitate the drawing up of timber-cutting contracts which would avoid much future trouble and litigation relating to the interpretation of references to insect and insect-killed timber.

Facts determined relating to the habit of the pine-destroying beetle of the Black Hills and the relation of other insects and fungi to the trees injured and killed by it suggested methods of future management which would prevent the loss of much timber, and contribute to a better public appreciation of the importance of Government forest reserves and the adoption of scientific forestry.

The facts which have been recently determined from special investigations of the troubles caused by the destructive pine bark-beetle, the chestnut timber worm, the oak timber worm, the giant root-borer, and a number of other principal enemies of Eastern forest trees have made available a fund of information which it is believed can be used to special advantage in formulating future plans for the management of Eastern forest reserves, systematic forestry work, conservative lumbering, etc.

The new facts determined during recent investigations in California, Oregon, Washington, and Idaho relating to the habits of the destructive enemies of the redwood, Monterey pine, Western yellow pine, sugar pine, Jeffery pine, shore pine, mountain pine, and lodgepole pine, and the Western hemlock, Douglas spruce, Englemann spruce, several species of fir, the Western larch, and Western cedars, have made available a fund of information which will be of special service in future studies of the enemies of the principal forest trees of the Western forest reserves.

The extent and magnitude of depredations by insect enemies of the forests and forest products of this country; the comparatively meager knowledge of the essential features in the life history, habits, and natural enemies of the principal depredators on which to base conclusions relating to methods of control or prevention; the possibility, as has been demonstrated, of future detailed investigations leading to the discovery of methods of preventing a large part of the losses; the facilities afforded in the extensive Government reserves and in large private areas where systematic working plans and forest management have been adopted, together with the information available from the results of investigations in this country and Europe, seem to warrant the recognition of forest entomology as a distinct branch of economic science.

The address was most heartily received, and, on motion of Mr. Howard, Mr. Hopkins was voted the thanks of the Association for his able presentation of this very important subject. The discussion of the address was postponed until the opening of the afternoon session and the regular business of the association was taken up. The discussion, however, is here inserted in connection with the address for the sake of continuity.

Mr. Smith stated that he had been much impressed by the address. He thought the subject one of the most important in its way in the United States, and the presentation of much value to entomologists. He knew that there was much injury done to forest trees by insects, but some things in the address impressed him as being contrary to his own experience, especially the statements about the giant root-borer (*Prionus laticollis*). In his experience, though that insect appeared quite generally in oak forests, he had not found it in that tree. According to his observation an old pine log was almost certain to become infested by the larva and to become its home. He had a large amount of material showing this. The line of work followed by him was quite different from that followed by Mr. Hopkins, and he would place the damage done by forest fires far ahead of that done by insects. Mr. Smith considered that in New Jersey the insects followed the fires. In that State forests are not in as large areas as in many other places, but in comparatively small blocks. Most of the fires are caused by sparks from the railroads, and after that the insects come in and complete the work done by the fires. Mr. Smith's point was not that Mr. Hopkins had been incorrect in his statement, but that what he said was contrary to his own observations in other localities. However, the facts may be different under different conditions. There was one insect in hickory (*Agrilus* sp.) that he had found cutting off the branches. It would work up and down for a little time under the bark, and would then start around the branch and make galleries to the center, until it had actually cut it off. Only recently he had found a number of specimens that had been cut off in this way.

Mr. Hopkins stated that in his investigations of oak trees he had found the giant root-borer to occur around the roots, and had dug them out in large numbers from living as well as dead tissues.

Mr. Smith stated that he had found them in the roots of cherry trees, working in something like the way described by Mr. Hopkins. According to his observations, except in the case of the blackberry, this insect would not breed in entirely living tissue; and he always assumed that, wherever borers were found in the roots of trees, the roots had been injured by some other cause. The insects are very common in pine logs in southern New Jersey.

Mr. Smith further stated that another point which had interested him was in reference to the carpenter worm (*Prionoxystus robiniæ*). It was stated to be a very common insect in the scrub oaks. In southern New Jersey, in the second growth from 6 to 8 inches in diameter, the larvæ got in year after year at the same point. They enter by preference at the place where other insects have made their entrance. If the tree is cut down, one can readily determine the time when the first insect entered. Comparatively small additional borings are made to the original one by succeeding broods. He had made sections in some cases that seemed to indicate that the tree had been infested for at least thirty years. He had found small larvæ working out from the end of old galleries. He thought this case offered a good illustration of the resisting power of trees. Those oaks that were most generally infested had certainly stood up for years under the attacks of the borers. He had noted several interesting cases, showing the relation between the woodpecker and carpenter worms, which indicated that sometimes there may be two woodpeckers after the same larva, and there were many cases where the history of these occurrences have been written out in the tree.

Mr. Felt stated in this connection that he had observed in the parks in Buffalo that the carpenter worm was very common in ash trees and in some sugar maples in St. Lawrence County, and in each instance they went to the heart of the tree. He was inclined to agree with

Mr. Smith that successive generations increased the length of the burrows. He had never seen a case of trees attacked by this insect being broken off by winds. He questioned if the species had been accurately determined in all cases, and thought that possibly there might be more than one species involved.

Mr. Smith was of the opinion that there was but one species engaged in New Jersey, and that this was the very common species. He stated that the imported *Zeuzera pyrina* worked the younger trees in such a way as to weaken them by going around the trunk and girdling it completely under the bark; then the first heavy wind would carry the tree to the ground.

Mr. Felt stated that another species (*Cossus centerensis*) occurred in the vicinity of Albany in poplars, and that its work was quite different from that of the carpenter worm.

Mr. Smith replied that in New Jersey there was another native species which was smaller than the one under discussion; but its habits of boring were different, and the species is quite rare.

Mr. Howard remarked that the Division of Entomology had recently made some examinations, and had found that oaks infested by the oak carpenter worm (*Prionoxystus robiniæ*) were noticeably smaller than trees not infested. The same year the insects were all destroyed in the trees found infested by the use of carbon bisulphid injected into the holes. Six months after he had published his paper on shade-tree insects he had been obliged to change his relative rating of oaks on account of this insect.

Mr. Smith remarked that he had used this method against the wood leopard moth in private grounds in the vicinity of Jersey City. The species has now spread to New Brunswick, but he did not regard it as a dangerous insect there. He had been watching it for many years, as it slowly spread from one city to another. The native birds kept it in check outside the sparrow range; but he had found it occasionally in nursery examinations close to cities, and here the insects might be very abundant, there being no native birds to keep them down. He had found the larvæ almost every year, but rarely in an orchard or on fruit trees, except such as were inside of city limits.

Mr. Scott called attention to a rather remarkable occurrence of one of the powder-post beetles which occurred in a dwelling on Washington street, Atlanta, Ga. His attention had been called to it by one of the inmates of the house, who requested him to make an examination. The trouble had existed for a week, and every day it had been necessary to remove the carpets from the floors and sweep up. An investigation of the cellar of the house and the floor above revealed that the timbers were thoroughly riddled by the tunnels of this beetle. He advised that the city building inspector be called, as the house appeared to be dangerous. He sent specimens of the insect's work to Dr. Howard with the request for a remedy. So far as he knew, nothing had been done and the usual remedies for injury of this character were here of but little use.

Mr. Sanderson stated that he had had some experience in his own house with a small beetle, about one-third of an inch long, the species being unknown to him. He could advise no means of killing it.

Mr. Quaintance asked if there had been any experiments made in fumigating to rid houses and cellars of white ants.

Mr. Marlatt said that it was very probably true that the subterranean colonies of the white ant would not be reached by the gas treatment, but that if the flooring could be loosened and the gas put as near as could be to the infested region, a great deal of benefit might result. The trouble would come, however, from the fact that the white ant colonies had numerous branches, and many of these would be beyond the foundation of the house. With regard to the use of creosote, he stated that for several years past the recommendation of the use of this substance had been made by the Division of Entomology, and that it was mentioned by himself in a recently published circular on the white ant. The use of creosote referred to was more in the nature of forcing it through the body of the timbers, as well as coating and soaking the exterior, and when so done it was believed to be a very effective means of preventing white-ant damage. The chief objection to it was the expense of the treatment.

Mr. Smith related an experience from New Brunswick, N. J. In one of the churches there had been trouble, and, in taking out the old organ, the timbers were found to be riddled by white ants. He had been consulted in the matter, and, in accordance with his suggestions, the worst infested timbers were removed and replaced with iron beams. Where it was necessary to keep wood, this had been soaked in a creosote preparation. Up to the present time he had heard nothing further of the matter.

Mr. Osborn remarked that it is almost necessary to find the nests of these insects to treat them, but did not consider gas would be effective if the insects were locked up in the timber. He was of the opinion that it would be difficult to kill them by fumigating, as the fumes of the gas did not penetrate to any extent.

Mr. Scott stated that he had spent a number of hours in an attempt to locate the nests of white ants, but that they were hard to find. Soaking timbers with creosote, as stated by Dr. Smith, had been used at different times by him in the South, but had not proven to be of much value. He thought that possibly some system of forcing creosote through the wood might be of value. He had frequently suggested that this be done, but the expense of the creosote seemed to be an objection, and he considered it of little value.

Mr. Hopkins called attention to a very excellent report from the Bureau of Plant Industry, by Dr. Herman von Schrenk, on the treatment of timber for fungi and insects.

Mr. Felt called attention to the fact that in New York State, when they had been suffering from drought, the pine trees had been very badly attacked by bark-borers. The fruit-tree bark-beetle had also been causing injury in the last two years. He had wondered what the cause of this was, and it appeared that this outbreak apparently began at the close of two or three excessively dry years. There was an excessive drought in July and August in that section in 1896, and the trees suffered considerably.

Mr. Hopkins stated that he had noticed that it was claimed that much injury had been caused by drought, but that he was a little skeptical as to the effect of drought on large trees. He had examined a number of the spruce trees, some growing on rocks, and others in the lowlands, where there should be an abundance of moisture.

Mr. Burgess asked Mr. Hopkins if the elms in the woodlands had been much attacked by *Saperda tridentata.* In Cincinnati, a great many of the elms had been seriously affected, and they were losing a large number of their trees. He desired to know if the injury had been general or not.

Mr. Hopkins replied that he had not observed this species in the forest elms in West Virginia.

Mr. Smith stated that, in the case of trees that had been infested by the carpenter worm in the south Jersey pines, he thought that fully nine-tenths of the caterpillars were taken out by woodpeckers. In every tree that is less than 6 inches in diameter, the birds can get at the larvæ without trouble.

Mr. Felt, in reply to Mr. Burgess's question, stated that he had observed the work of *Saperda tridentata* somewhat extensively in New York, and found it confined to shade trees, and not to forest trees, and in some places he had noted considerable injury. Trees 12 to 14 inches in diameter were more commonly injured; in his experience the insect was confined to the American elm.

The secretary presented the following names for membership in the association: Mr. Percy B. Gregson, Waghorn, Alberta, Northwest Territory; Mr. H. W. Peal, Indian Museum, Calcutta, both proposed by Dr. Howard; and Prof. Wm. Lochhead, Guelph, Ontario, proposed by Dr. Fletcher. Messrs. Peal and Lochhead, being official entomologists, the secretary was directed to add their names to the list of members. On motion, Mr. Gregson was elected to membership.

Mr. Felt proposed the name of Mr. J. J. Barden, nursery inspector in in the State of New York. Mr. Osborn moved that a committee of three on membership be appointed to consider the application of Mr. Barden and others for membership. The chair announced as this committee Messrs. Osborn, Smith, and Felt.

The report of the secretary and treasurer was next read, and on motion of Mr. Howard was adopted.

Mr. Smith thought it well to appoint a committee to propose an amendment to the constitution which would permit the revision of the membership lists, and, after considerable discussion, he moved that the matter be referred to the committee on membership already appointed, which was duly seconded and carried.

The secretary next read letters from members who were unable to be present, but extended their best wishes to the association.

On motion of Mr. Howard, a committee of three was appointed to arrange the programme, as follows: Messrs. Marlatt, Smith, and Quaintance.

It was moved and carried, that committees of three each on nominations and resolutions be appointed by the Chair. The Chair stated that these committees would be announced later. The meeting then adjourned to reassemble at 2 p. m.

AFTERNOON SESSION, FRIDAY, JUNE 27, 1902.

The meeting was called to order by President Hopkins, who announced the first paper on the programme to be by Mr. A. F. Burgess.

NOTES ON THE USE OF THE LIME, SULPHUR, AND SALT AND THE RESIN WASHES IN OHIO.

By A. F. Burgess, *Columbus, Ohio.*

Owing to the serious difficulty encountered in successfully treating fruit trees infested with San Jose scale, a limited number of experiments were planned by Prof. F. M. Webster to test the efficiency of the lime, sulphur, and salt wash in Ohio. For this purpose young apple trees were selected about 10 to 12 feet in height and badly incrusted with scales. Mr. Wilmon Newell, late assistant entomologist to the Ohio experiment station, prepared the wash and thoroughly sprayed the trees December 31, 1901. The formula used was that recommended in Bulletin No. 3 (n. s.), Division of Entomology, viz, 40 pounds of lime, 20 pounds of sulphur, and 15 pounds of salt, with the addition of enough water to make 60 gallons of wash after these ingredients had been boiled as prescribed.

The rainfall at Wooster for the month of January amounted to only 0.63 inch, and was distributed as follows:

	Inch.
January 3	0.02
January 11	.05
January 12	.05
January 16	.02
January 21	.40
January 26	.05
January 27	.02
January 29	.02

During the last part of the month snow fell instead of rain, but as it did not adhere to the trees to any great extent, its melting caused little of the wash to be removed.

The climatic conditions were what would be considered favorable for the successful use of this wash.

No careful inspection of the trees was made until May 24, 1902, but previous hasty examinations showed that a large number of the scales were becoming loosened on the trees and were falling to the ground. On the latter date the writer inspected these trees, and was unable to find any living scales whatever, except a few females which were nearly full grown. Ten per cent of the females that had reached this degree of maturity were found to be alive, but on comparing the total number of living scales present on the trees with the number present before the trees were sprayed it appeared that at least 98 per cent had been destroyed.

In Ottawa County the lime, sulphur, and salt wash was prepared by several owners of orchards, and applied to peach trees late in March, 1902, with satisfactory results. In one instance, a heavy storm of hail and rain fell shortly after spraying, and washed considerable of the deposit from one side of the trees. The owner, fearing that the wash would not be effective, resprayed some of the trees on this side, very lightly, with crude oil. On June 14 an occasional live scale could be found, but the treatment appeared satisfactory. On examining some of the trees sprayed at the same time, but which had not been resprayed on one side with crude oil, no perceptible difference was apparent in the number of living scales present.

A single case has been reported on Catawba Island where peach twigs have apparently been injured by this wash. The spray was prepared by the owner, the same formula being used as in the Wooster experiments. A large block of thrifty peach trees was sprayed on March 22 and 26, the weather following being dry and favorable for the effective use of the wash. On examination June 14, the writer found that many of the twigs on some of the trees had died from 4 inches to over a foot from the terminal bud. The foliage below the dead twigs was green and healthy in appearance, but the crop of fruit had been greatly reduced. The greater part of the trees in this orchard, treated in the same manner, showed no injury, hence it is difficult to understand the exact cause of the damage.

The resin wash was also prepared and applied by Mr. Newell to apple trees slightly infested with the San Jose scale. It was made as directed in the bulletin previously mentioned, using 20 pounds of resin, 5 pounds of caustic soda, and 2½ pints of fish oil, and, after boiling for four hours, it was diluted with sufficient water to make 100 gallons. The spraying was done January 8, and the trees were not examined until May 24. At this time only a single living scale was found, although several hundred scales were carefully inspected.

Mr. W. H. Owen sprayed a row of badly infested trees in his peach orchard on Catawba Island with a resin wash, but the formula contained more fish oil than the one above quoted, and caustic potash was substituted for caustic soda.

The trees were sprayed April 15 and 22, and the fruit buds apparently sustained no injury, as a good crop of peaches is growing. It was estimated, after examining the trees June 14, that 98 per cent of the scales had been destroyed.

The results of the limited number of experiments this year indicate that these washes can be used in Ohio with good success, if climatic conditions are favorable, and if the preparation and application is careful and thorough. Whether orchardists will be able to duplicate the results of these tests as satisfactorily on a large scale and under different weather conditions can only be demonstrated in this State by the work of another season.

Basing the cost of materials on quotations received from wholesale firms in Columbus, the lime, sulphur, and salt wash can be prepared for a little over one cent per gallon. The resin wash is considerably cheaper, unless a more concentrated spray is desired. These estimates do not include the cost of preparing the wash, which takes considerable time, and should the materials be bought at retail prices the expense would be increased.

After the conclusion of Mr. Burgess's paper, it was voted to defer discussions until all of the papers on this subject had been presented.

Mr. E. P. Felt then presented the following paper:

EXPERIMENTAL WORK IN NEW YORK STATE AGAINST THE SAN JOSE SCALE.

By E. P. Felt, *Albany, N. Y.*

The apparent complete destruction of the San Jose scale following the spraying operations of the writer last December is in marked contrast to some results obtained in other sections of the State. The work was done December 11, 1901. The day was an ideal one, there being very little or no wind most of the time and the temperature ranging from about 30° F. in the shade to 68° in the sun. The trees were dry, and, despite the fact that there had been considerable cold weather and much snow the previous week, even the very bases of the trunks of the trees were exposed and dry and the insecticides could therefore be applied to the greatest advantage. The sun shone brightly most of the day, and it was one which would be characterized as a drying day. The apple orchard, where most of the work was done, consisted of over 60 young trees, many of which were in an exceedingly bad condition on account of the abundance of the San Jose scale and a number were badly infested by the round-headed apple-tree borer.

A 20-per-cent mechanical emulsion of a light, crude petroleum (41.1° Beaumé), obtained from the Derrick Oil Company, was applied to 22 apple trees and to 14 plum, pear, and quince trees. Examinations this spring, even as late as June 12, showed that the apple trees had apparently suffered little or no injury from the insecticide. These trees are not in good condition this spring, but this is due almost entirely to serious injuries inflicted by the two insects above named. The Clapp's Favorite pear trees were injured somewhat, several limbs being killed, the bark cracking in places and some suckers being thrown out. The Dutchess pear trees suffered less and the Bartlett's apparently escaped without any injury, being in excellent condition and two of them bearing considerable fruit. The tips of a number of limbs on a Globe peach tree were all dead this spring, but this can not be attributed to the insecticide, as some untreated trees suffered in the same manner. The treatment may, however, have facilitated winter killing. Several Meeche's Prolific quince trees were also sprayed, without the slightest deleterious effects being observed.

Good's potash whale-oil soap No. 3, two pounds to the gallon, was applied on the same day to 23 apple trees and 10 pear, plum, cherry, and quince trees. The Clapp's Favorites, Bartlett's, Beurre d'Anjou, and Vermont Beauty pear trees suffered no injury and bear some fruit. A yellow gage plum has no fruit and a Magnum Bonum plum bears considerable. Both trees are in excellent condition and evidently suffered very little or no harm from the insecticide, unless the fruit buds of the first-named variety were killed, which is hardly probable.

Good's tobacco whale-oil soap No. 6, two pounds to the gallon, was also tested under the same conditions on 10 apple trees and 18 green gage plum trees. The apple trees showed very little or no injury, while most of the plum trees have suffered harm, which is shown by the majority developing a considerable number of adventitious shoots.

Two small apple trees were painted with linseed oil, the raw product being used on one and the boiled on the other. The first was killed outright by the application and the second nearly so. This substance is so dangerous that its use in the fall can not be recommended.

All of these applications have, so far as present examinations can determine, given most excellent results so far as insecticidal purposes are concerned. Many of the trees were very badly encrusted with the San Jose scale and apparently not a single scale has survived the treatment. This statement may need modification as the breeding season advances, but the present indications are very satisfactory indeed.

REPORT OF EXPERIMENTS WITH LIME, SALT, AND SULPHUR WASH AGAINST THE SAN JOSE SCALE IN MARYLAND.

By A. L. QUAINTANCE, *College Park, Md.*

As a result of experiments by the entomologists of the Division of Entomology, United States Department of Agriculture, and others, it has perhaps been generally accepted that the lime, salt, and sulphur wash, so effective in California against the San Jose scale, is of comparatively little value in the East, owing to our more rainy climate. In the past few years, however, numerous reported cases of its successful use have awakened renewed interest in the wash, and further experiments have seemed desirable, particularly in connection with a record of weather conditions, which seem to be an important factor in the results following its application.

The past winter applications of the lime, salt, and sulphur wash were made in three different localities in Maryland, namely: College Park, Prince George County; Annapolis Junction, Howard County; and Sharpsburg, Washington County.

Experiment I.—At College Park, 20 five-year-old Japan plum trees, badly infested with scale, were treated on March 4. A Pomona barrel sprayer was used, fitted with Seneca nozzles. The wash was made according to the following formula:

Lime	pounds	40
Salt	do	15
Sulphur	do	20
Water	gallons	60

The sulphur and 20 pounds of quicklime were placed in a barrel with 20 gallons of water and steam cooked for one and one-half hours, after which the salt and the remaining lime were added and the whole cooked for one-half hour longer, after which the balance of the water was added.

At the time of making the application the weather was cloudy, and the temperature ranged somewhat above the freezing point all day. Soon after the work had been finished a light snow began to fall, which alternated with rain and sleet during the night and most of the following day. The trees were wet almost continuously for a period of twenty to twenty-two hours immediately following the application of the wash. Several succeeding days were clear and bright, with the temperature ranging mostly above the freezing point. The precipitation and aspect of sky from March 4 to May 31 is given in the following table, as taken from the weather record book of the United States Weather Bureau, as recorded by Prof. W. T. L. Taliaferro at the experiment station, about one-fourth mile from the treated trees:

Record of weather from March 4, 1902, to May 31, 1902, in connection with lime, salt, and sulphur experiment at College Park, Md.

Date.	Precipitation.	Character of weather.
	Inches.	
March 4	1.07	
5	.41	
6–11		Clear.
12	.34	
13	Trace.	
14–15		Clear.
16	.29	
17–27		Clear.
28	.71	
29–30	.31	
31		Cloudy.
April 1		Cloudy.
2–3		Cloudy
4	.06	
5–6	.05	
7	1.10	
8	40	
10		Part cloudy.
11–13		Clear.
14	Trace.	
15		Cloudy.
16		Part cloudy.
17		Clear.
18	Trace.	
19–25	Trace.	Clear.
April 26	0.31	
27		Clear.
28	.14	
29	.19	
30		Clear.
May 1		Clear.
2	.41	
3–6		Clear.
7	.09	
8–10		Clear.
11		Part cloudy.
12		Clear.
13	.03	
14–17		Clear.
18		Part cloudy.
19	.33	
20	.19	
21–22		Clear.
23	.64	
24–25	.69	
26	.32	
27		Part cloudy.
28	Trace	
29–31		Clear.

As will be noted in the table, there were 1.48 inches precipitation on the night and succeeding day following the application. There was a light rain of 0.34 inch on March 12, eight days after date of application. A light rain also occurred on the 16th, and 0.71 inch fell on the 28th, with a precipitation of 0.31 inch during the 29th and 30th. There was thus a total precipitation from March 4 to 31 of 3.13 inches. During April rain fell at seven different times, with a total for the month of 2.25 inches. During May rain fell on eight different dates, with a total of 2.70 inches.

Frequent examinations of the treated trees were made to note the effect of the wash on the scales. The earlier examinations indicated that a very large percentage of the scales had been killed. Later examinations, however, showed that these estimates had been placed too high, and in the final examination, on June 2, of many branches and twigs from different trees the percentage of scale killed was placed at from 55 to 60 per cent. At this time the young lice were very abundant, many having settled on the limbs, leaves, and fruit. Scraping the infested branches with a knife revealed the bright, yellow bodies of the mature females in great numbers, and running the blade flatwise pressed out an abundance of oily fluid from the scales.

On the whole, the treatment was far from satisfactory, and was not sufficiently so to render the use of the wash profitable in comparison with some of the other insecticides used against this species.

Experiment II.—The test at Annapolis Junction was made on an orchard of 225 ten-year-old apple trees and about 50 two-year-old peach trees. There was a general sprinkling of the scale throughout the orchard, and many trees were quite badly infested, the trunk and limbs being mostly incrusted with scale. The wash as made up was identical with that used at College Park, but was cooked in a large iron boiler instead of in a barrel by the use of steam. The wash was applied with the same apparatus, and when finished the trees were quite thickly and uniformly coated with the mixture. The treatment was made on March 27 and 28, the weather being clear, with but little wind. The following weather record as furnished me by Col. W. S. Powell, on whose farm the work was conducted, is of interest in this connection:

March 29. Warm, with showers in afternoon.
March 30. Showers in afternoon.
March 31. Snow and rain; cold winds.
April 1. Cold winds.
April 2. Cold winds.
April 3. Fair.
April 4. Light rain.
April 5. Fair.
April 6. Light rain.
April 7. Cloudy.
April 8. Driving rain all day.
April 9. Light rain.
April 10. Fair and cold.
April 12. Fair.
April 13. Fair and windy.
April 14–28. Fair, with variable temperature.
May 6. Fair, with variable temperature.
May 7. Rain during night.
May 8–12. Fair.
May 13. Rain in afternoon.

The weather record was not kept after May 13, as later than this it was not considered as having any bearing on the experiment.

A careful examination of infested twigs from different trees on May 10 led to the conclusion that a considerably higher percentage of scale had been killed than a subsequent examination on June 13 proved to be the case. On this date many young scales were crawling, and very many live scales were exposed by scraping the infested limbs with a knife. After an examination of many trees, both peach and apple, the percentage of dead scale was placed at from 45 to 50.

In considering the weather record for this test, it will be observed that rain fell on the three days succeeding the application, and on

April 8, eleven days after the treatment, there was a driving rain all day. Rain fell in varying amount at eight different times during the course of the thirty days following the application of the wash.

A slight variation was made in the treatment applied to two rows of apple trees, which might here be mentioned. These trees were sprayed with the usual lime, salt, and sulphur wash, to which refined glue had been added at the rate of 3 pounds to the barrel of water. An appreciable difference in the effectiveness of this wash was to be noted, an increased percentage of scale of not less than 18 or 20 per cent having been killed.

In the foregoing tests the results were decidedly disappointing, so far as the effectiveness of the wash was concerned, but considered in connection with the weather conditions which prevailed it is not likely that applications of other insecticides would have given anything like usual results.

Experiment III.—The third test of the wash was made in an orchard of 5-year-old peach trees on the farm of Mr. S. S. Stouffer, Sharpsburg, Md. A block of about 50 trees was selected and treated with the wash on March 22, the day being bright, warm, and calm. Two formulæ were used, the 40-15-20 to 60 gallons of water, and the 30-8-12½ to 50 gallons of water. The rains which occurred, as reported by Mr. Frisby Smith, who also applied the spray, are as follows:

March 28. Light rain.
April 8 and 9. Heavy rain.
May 19. Heavy thunder storms.
May 25. Heavy thunder storms.

The trees in this plat were examined June 19, and the results were quite different from those previously recorded. Live scales were quite hard to find, although some trees were rather badly infested with them. On the whole, the percentage killed was placed at from 98 to 99 per cent. No appreciable difference was to be noted in the results from the different formulæ. The trunks and larger limbs were still coated with the wash, so that the scales were considerably obscured.

The lime, salt, and sulphur wash was used by Mr. Stouffer one year ago this spring on a part of his orchards with gratifying results, and his entire orchard was sprayed with it the present spring. Three years ago the scale was very serious in this orchard, some trees having been killed and many seriously injured. At the present time the insect is under complete control, and no fear is now felt as to the possibility of keeping it in check with this treatment.

SOME PRACTICAL EXPERIMENTS WITH VARIOUS INSECTICIDES FOR THE SAN JOSE SCALE IN GEORGIA.[a]

By W. M. Scott, *Atlanta, Ga.*

The Georgia State department of entomology was established in March, 1898, and at that time, as shown by inspections made later, the San Jose scale had become established in 57 counties, including the leading orchard sections of the State. No system of treatment had been adopted, most of the owners of infested orchards not having even determined the cause of the trouble.

In a few instances, however, some knowledge of this pest and its treatment had been gained through correspondence with the Division of Entomology and the Georgia Experiment Station. In the Tifton section some 50,000 peach trees had been subjected to the gas treatment, and whale-oil soap was being used quite extensively in Randolph County, but as a rule practically nothing was being done to control this pest. The gas treatment, although giving good results, proved to be too cumbersome, and the soap washes, owing perhaps to lack of thorough application, were unsatisfactory.

Our State law was such as to compel the treatment of infested orchards, and it was incumbent upon the newly appointed entomologist to furnish the remedy. After some preliminary experiments the oil-water treatment was adopted and a 25 per cent strength of kerosene was recommended for the winter of 1898–99. The results were generally satisfactory, but it was found advisable to reduce the strength to 20 per cent. Experiments with crude petroleum, made the following year, gave this substance the preference, better results being obtained with it than with corresponding strengths of kerosene. For several years, therefore, kerosene and crude oil in mechanical mixture with water have been very extensively used against the San Jose scale in Georgia, and, though on the whole successful, there have been several cases of more or less serious damage to the treated trees. In most cases the damage has been accurately traced to some defect in the pump, carelessness in the application, or other causes within the power of the orchardist to control. But there have been a few cases where the resulting damage could be attributed to no fault of the operator. These adverse results gave rise to some distrust of the oil sprays, which was augmented by the arguments of certain vendors of sure-cure washes and compounds guaranteed to exterminate the scale without damage to the trees.

In order to test these "cure-all" compounds and other better known scale washes in comparison with the oils officially recommended by the Department, a series of extensive experiments was planned, for the execution of which an orchard of 17,000 2-year-old peach trees was secured from Mr. S. H. Rumph, at Marshallville, Ga. In addition a near-by orchard of Mr. F. J. Frederick's, consisting of about 2,000 4-year-old peach trees was used, more particularly as a test of the insecticides upon bloom buds.

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[a] For valuable assistance in the execution of these experiments the writer is indebted to Mr. W. F. Fiske, who personally conducted the larger portion of the work with the soaps and caustic washes; and to the owners of the orchards, who furnished the teams and labor.

The larger orchard was divided into plots of 400 trees each, and these were so arranged that each plot contained five or more varieties of peaches. The orchard was badly infested with the San José scale, less than 10 per cent of the trees being entirely free, and from 10 to 40 trees in each plot being either completely encrusted or nearly so. The orchard became infested from local spread during the first season after planting, and until the experiments were begun in November, 1901, it had received no treatment.

In the Frederick orchard some scales were found on every tree, and about 25 per cent of the trees were quite badly infested.

The following substances were used in the experiments:

- Oils:
  - Pennsylvania crude, 43° gravity.
  - Refined kerosene, 150° flash test.
  - Standard Oil Company's fuel oil.
  - California distillate.
- Soaps:
  - Leggett's Anchor brand.
  - Leggett's whale-oil soap compound.
  - Good's No. 3.
  - Good's No. 6, tobacco.
  - Turpentine soap.
- Caustic washes:
  - Lime, sulphur, and salt wash.
  - Crude potash.
  - Resin wash.
  - Carbolic acid emulsion.

It should be explained that during the course of the winter a large number of the scales perish without treatment. The females that have reached maturity and commenced breeding rarely survive the winter. In making up results, therefore, only the immature overwintering individuals were counted.

PETROLEUM OILS.

Owing to delay in obtaining the crude oil no comparative tests were made until January 15, when the work with oils was properly begun. From that date applications were made at various intervals until March 7, at which time the fruit buds were beginning to part their petals. During the first week in December, however, kerosene in soap emulsion was used at strengths of 10, 15, and 20 per cent.

Nearly all sorts of weather conditions were met with, and an excellent opportunity was thus afforded for testing the influence of the weather upon the effect of the oil sprays. Applications were made on fair and cloudy days, immediately before and after rains, early mornings, and late afternoons. Peculiarly enough, however, the different conditions attending the various applications made no apparent difference in the effect of the oil upon the trees or scale insects; likewise no appreciable difference in the results could be detected between early and late applications. This was rather surprising, as it was expected that applications followed within a few hours bv clouds and rain would result in damage to the treated trees.

No attempt is made to record the details of these experiments here. Below some of the tests are summarized in a general way. Applications having been made at different seasons and under different weather conditions, a large number of plots were required and many of these could not be included in the tables.

Crude petroleum.—A summary of the applications and results in the Frederick orchard is given in Table I. It is not deemed necessary to give a similar table of the work in the Rumph orchard which, though on a much more extensive scale, does not give results materially different from those contained in this table. It is worthy of note, however, that the trees in the Rumph orchard received no apparent damage from any strength of oil applied, while some injury was noted in the Frederick orchard, attributable in part to defects in the pump and possibly to some extent to the condition of the trees, the Rumph orchard not having yet come into full bearing.

TABLE I.—*Results from applications of crude petroleum.*

Number of trees.	Age.	First application.		Second application.		Date of final examination.	Effect on scale.	Effect on trees.	General notes.
		Date.	Strength and form.	Date.	Strength and form.				
175	4 years	Jan. 17	15 per cent in mechanical mixture.			Apr. 16	Less than 1.5 per cent alive.	None, or at most very slight.	Cloudy, and trace of rain on following day (Jan. 18).
25	do	do	do	Mar. 7	15 per cent in mechanical mixture.	do	Estimated 2 per cent alive.	None	Mar. 7 fair and bright; slight precipitation on the 8th.
175	do	Jan. 18	20 per cent in mechanical mixture.			do	Estimated less than 0.5 per cent living.	8 trees injured, none fatally.	The damage was caused by imperfection in working of pump. All injured trees in these two plats adjacent.
25	do	do	do	Mar. 7	20 per cent in mechanical mixture.	do	do	12 trees more or less injured—some only slightly, none fatally.	
175	do	Jan. 20	15 per cent in mechanical mixture.			do	No live scale found	4 trees injured, 2 severely.	Day fair, followed by 0.75 inch rain at night.
25	do	do	do	Mar. 7	25 per cent in mechanical mixture.	do	Estimated 3 per cent live scale found.	Very slight	High percentage of living scale due to portion of twig missed by spray.
175	do	Jan. 24	15 per cent in soap emulsion.			Apr. 17	Estimated 7 per cent live scale found.	Very slight, or none at all.	Portions of limbs on 2 trees found not hit by spray.
25	do	do	do	Mar. 7	15 per cent in soap emulsion.	do	Estimated 0.5 per cent live scale.	None	Jan. 24 cloudy, with trace of rain.
175	do	do	20 per cent in soap emulsion.			do	Less than 0.5 per cent of live scale.	do	
25	do	do	do	Mar. 7	20 per cent in soap emulsion.	do	No live scale found out of 1,100 counted.	do	
175	do	do	25 per cent in soap emulsion.			do	No live scale found out of 450 counted.	do	
25	do	do	do	Mar. 7	25 per cent in soap emulsion.	do	No live scale found out of 500 counted.	do	

Considering the effect upon both the scale insects and the treated trees, the results were slightly in favor of crude oil applied in the form of emulsion with soap at the strength of 20 or 25 per cent. In many cases 25 per cent oil gave no better results than a 20 per cent strength, the latter proving sufficient to destroy all scales with which it came in contact. Moreover, it was found unnecessary to make more than one application, although the second application doubtless killed some insects that were not reached by the first. No apparent damage to the trees or fruit buds could be definitely attributed to the emulsion. Trees that received two applications of a 25 per cent strength showed little or no ill effect.

Equally as good results were obtained from crude oil applied with the mechanical mixing pumps when a uniform discharge could be obtained. The Gould "kero-water" pump with two 20-foot leads of hose was used and, though apparently the best pump of this nature on the market, it can not always be depended upon for a uniform percentage of oil. For some unexplainable reason the discharge of either oil or water may cease at varying intervals; and even if this regularity lasts only for a moment, a tree may be seriously injured or the scale infesting it may escape unharmed. Moreover, owing to the construction of the pump, a slightly greater percentage of oil is usually discharged through one lead of hose than the other; and with nozzles having small apertures (one-twentieth inch Vermorel were used) there is always some separation of the oil and water in the hose and consequent variations in the composition of the spray from one instant to another. However, it should be explained that with constant care and frequent tests excellent results can be obtained by the use of these pumps. In the experiments no great difficulty was encountered and, with the exception of a very few injured trees and lack of effect on the scale in rare cases, the results compare favorably with those obtained from the soap emulsion.

Kerosene.—What has been said of the comparative value of crude oil in mechanical mixture and in soap emulsion applies equally well to kerosene, the latter form of application giving slightly more uniform results in both cases. The results from a portion of the plats treated with kerosene are contained in Table II, which is made from notes on the early applications of emulsion in the Rumph orchard and later applications of the mechanical mixture in the Frederick orchard.

TABLE II.—*Results from applications of kerosene.*

Number of trees.	Age.	First application.		Second application.		Date of final examination.	Effect on scale.	Effect on trees.	General notes.
		Date.	Strength and form.	Date.	Strength and form.				
175	4 years	Jan. 20	15 per cent in mechanical mixture.			Apr. 17	Estimated less than 1 per cent living scale.	None	Day fair, followed by 0.75 inch rain at night.
25	do	do	do	Mar. 7	15 per cent in mechanical mixture.	do	Estimated 3 per cent living	do	The living scale in this plat found on incrusted trees.
175	do	Jan. 23	20 per cent in mechanical mixture.			do	Less than 1 per cent living scale.	do	
25	do	do	do	Mar. 7	20 per cent in mechanical mixture.	do	1 per cent living scale	do	All live scale found were on underside of one limb.
175	do	do	25 per cent in mechanical mixture.			do	Less than 1 per cent live scale.	do	
25	do	do	do	Mar. 7	25 per cent in mechanical mixture.	do	Less than 1 per cent live scale.	do	Mar. 7 fair, followed by slight rain on 8th.
100	2 years	Nov. 30	10 per cent in soap emulsion.			1st week in May.	10 per cent live scale	do	Strength clearly insufficient.
200	do	do	do	Feb. 24	15 per cent in soap emulsion.	do	Estimated 3 per cent living scale.	do	Weather fair on Nov. 30 and the day following.
100	do	do	do	do	20 per cent in soap emulsion.	do	0.1 per cent alive	do	
100	do	do	15 per cent in soap emulsion.			do	3 per cent alive	do	
200	do	do	do	Feb. 16	15 per cent in soap emulsion.	do	3 per cent still living	do	Feb. 16 very windy, and on that account spraying discontinued.
100	do	do	do	do	20 per cent in soap emulsion.	do	Only a few crawling young found.	do	
100	do	Dec. 4	20 per cent in soap emulsion.			do	Less than 1 per cent live scale.	do	Dec. 4 fair, followed by cloudiness and 0.08 inch rain on 5th.
125	do	Feb. 17	10 per cent kerosene in emulsion added to a 4 per cent emulsion of crude carbolic acid.			do	15 per cent living scale		Addition of carbolic acid of no avail.

At strengths of 20 and 25 per cent the results, on the whole, were quite satisfactory and such as to warrant one in continuing to recommend the use of kerosene (preferably in soap emulsion) for scale-infested orchards in Georgia, when crude oil can not be conveniently procured. The crude oil is cheaper and in practice appears to be considerably more efficient, owing to the residuum with which the trees remain coated for weeks after the application.

Fuel oil.—This substance was purchased from the Standard Oil Company with the intention of using it cautiously on only a few trees. On February 18, it became necessary to leave the work for a day in charge of the foreman, a white man, who was given explicit instructions for carrying out the experiment with crude oil in mechanical mixture. Through mistake he got hold of the fuel oil and very carefully carried out the scheme of experiments, thinking that he was using the high-grade crude oil. It was applied to about 1,000 trees in the Rumph orchard. Unfortunately the entire lot was used up before the mistake was discovered and no record was made of its specific gravity. It was applied at the rate of 10, 15, and 20 per cent as a first application and at the same strengths as a second application where the high-grade crude oil had been used a month before in corresponding strengths.

The results were quite surprising, in that the trees suffered no apparent damage even where the 20 per cent strength followed as a second application upon the high-grade oil. Some of the treated trees were slightly backward in putting out foliage, but they soon became vigorous and all indication of injury disappeared. The effect upon the scale was as good as that obtained with the high-grade oil. The 20 per cent strength killed more than 99 per cent of the scale and the 15 per cent strength appeared to be equally as effective, while at 10 per cent the vagaries of the pump became apparent in the results.

Distillate emulsion.—Ten gallons of this substance was obtained from California and used as recommended in that State. It was found that a strength of 1 part of the emulsion to 4 parts of water was required for efficient work against the scale. The results from weaker applications were unsatisfactory. The effect upon the treated trees was slightly injurious, but in no case seriously so.

SOAPS.

All the brands of soap mentioned above were tested more or less extensively, and to record the results from each would require too much space here.

The earlier applications (beginning December 2), except in the case of one brand of soda soap, were generally unsuccessful, owing, in part at least, to adverse weather conditions immediately following. The last series of tests (made March 6) were quite satisfactory, less than

1 per cent of live scale remaining on trees treated with a solution containing 2 pounds to each gallon of water. One and one-half pounds to the gallon, though killing much the larger portion of the insects, was notably less effective. Rain within twenty-four hours after treatment seriously interfered with the results, particularly when a potash soap was used. In one case 1½ pounds to the gallon was more effective than 2 pounds to the gallon applied the following day, both applications having been drenched with rain on the third day.

One hundred or more trees were used in each test, and the general effect (aside from that upon the scale) appeared to be more beneficial than otherwise. Some damage to fruit buds, not, however, of a serious nature, resulted from the early December applications. The spring work gave no ill effect.

CAUSTIC WASHES.

Lime, sulphur, and salt.—Three strengths of this wash were used, the standard formula (30 pounds of lime, 20 of sulphur, and 15 of salt) being diluted to 40, 50, and 60 gallons. It was applied at four different dates, February 28, March 3, 6, and 7.

February 28 was a fair day, with a slight breeze from the southwest during the forenoon, freshening into a brisk wind in the afternoon, rendering thorough work difficult. On March 1, 1.33 inches of rain fell, but the temperature (maximum, 58° F.; minimum, 33°) was cold for the season. On March 5, 0.23 inch of rain fell, followed by two fair days and a slight rain (0.02 inch) on the 8th. No more rain fell until March 14, when it commenced and rained through the 16th, during which time the precipitation amounted to 4.75 inches.

The more thorough observations were made during the first week in May, when it was found that the best results were obtained from the applications on March 3 and 6, which killed about 90 per cent of the scale. On the other plots as much as 20 per cent of the scale could be found alive. However, a more hasty examination, made June 4, showed that the insects were still dying and that before the wash should be exhausted the fatality would be much greater than the earlier observations indicated. The scaly covering of such insects as appeared to be alive were in many cases so corroded by the wash as to afford little protection to the insects. Contrary to expectation, the strongest solution gave no better results than those of greater dilution.

It might be said that the results upon the whole were somewhat gratifying and that further tests may prove the lime, sulphur, and salt wash to be a valuable scale remedy for Georgia. In the light of later knowledge it is quite certain that our method of preparation could be improved upon, as it now appears that some of our poor results were probably due in part to insufficient boiling.

Crude caustic potash.—Crude caustic potash in solution was used at strengths of 1, 2, and 3 pounds to 10 gallons of water. The first application (made in the fall) was of the medium strength, with results far from successful, owing perhaps to wet weather immediately following. The second spraying, March 6, gave the following results as shown by examination made May 6:

1 pound to 10 gallons, 25 per cent of scale alive.
2 pounds to 10 gallons, 3 per cent of scale alive.
3 pounds to 10 gallons, less than 1 per cent of scale alive.

No injury to the trees resulted, but the stronger solutions cut the hose very badly. It is clear, then, that potash used strong enough will successfully destroy the scale, but it is quite impractical to use it extensively at the required strength owing to its caustic effect upon both the hose and the operators.

Resin wash—One application prepared according to the standard formula was followed by no good results.

Carbolic acid emulsions.—Three different washes, of unknown composition, but consisting essentially of an emulsion of crude carbolic acid with varying proportions of oils, soap, and other ingredients, were given thorough trials. It was found that less than a 16 per cent strength of any of these washes was practically ineffective, and though 20 and 25 per cent strengths were reasonably effective, the cost would debar their use.

PRACTICAL WORK IN A LARGE ORCHARD.

In addition to the regular experiments, an orchard of 55,000 three-year-old peach and 1,000 plum trees belonging to Mr. W. C. Wright, of Fort Valley, Ga., was treated under the writer's supervision. Mr. Wright was very much alarmed over the condition of his orchard, and he made a special request of the entomologist to assume full control of its treatment.

Beginning August 8, 1901, the orchard was given an inspection row by row, which revealed 1,000 badly infested trees well distributed. From these centers of infestation the scale had spread generally in all directions, leaving only a small percentage of the trees entirely free. Beginning August 20, all the badly infested trees that had been located were sprayed with a 10 per cent strength of kerosene, using a knapsack "kero-water" pump. This checked the breeding of the scale, and was apparently the means of saving a large number of trees that would doubtless have perished before time for winter treatment.

From December 25 to January 2 each badly infested tree and with 15 or 20 adjacent trees were sprayed with a 15 per cent strength of kerosene, using a barrel pump. In this manner the 1,000 trees representing the centers of infestation had received two applications of oil

(10 per cent and 15 per cent, respectively) and about 1,500 trees one application before the general treatment of the orchard commenced.

It was intended that the entire orchard should be treated with crude petroleum, but delay in obtaining this substance necessitated the continuation of the use of kerosene. Taking the trees in regular order, regardless of previous treatment, 17,000 were sprayed with a 20 per cent strength of kerosene between January 3 and 23. The crude oil had then arrived, and from January 25 to February 7 28,000 peach and 1,000 plum trees were sprayed with a 20 per cent strength of this substance, which registered 43½° gravity on the Beaumé oil scale. The remaining 10,000 trees being detached from the main orchard and containing only a slight infestation of scale, were not taken into account in making notes. However, they were sprayed with a 20 per cent strength of kerosene, beginning February 11. The effect of the treatment was carefully watched, and at the end of three weeks after 20 per cent kerosene had been applied to the block of 1,700 trees in the general treatment, a small percentage of live scale insects could here be found. It was then too early to make a definite determination of the results, but the owner was not satisfied with the indications and the writer consented to another application to this block, advising 15 per cent kerosene, which was applied late in February.

Reviewing the treatment, a portion of the 1,000 badly infested trees was sprayed four times at different periods with kerosene at 10, 15, 20, and 15 per cent strengths, respectively, and the remainder three times with 10 and 15 per cent strengths of kerosene, respectively, followed by a 20 per cent strength of crude oil. A portion of the 15,000 trees that received 15 per cent kerosene before the general treatment commenced was sprayed with 20 per cent kerosene in January, followed by an application of 15 per cent kerosene late in February, while the other portion received a 20 per cent strength of crude oil. Then a portion of the trees that remained unsprayed when the general treatment commenced received a 20 per cent strength of kerosene, followed by a 15 per cent strength, while the other portion received a 20 per cent strength of crude oil only.

The entire work throughout the season was done in the most careful manner possible on a large scale. Six Gould barrel "kero-water" pumps were used, and these were supplied with oil by extra teams while the water was piped into the orchard. The work was done with negro labor, superintended by the owner of the orchard and two intelligent white men, who at short intervals tested the percentage of oil discharged and saw that every portion of the tree was moistened with the spray. When any part of the tree was found dry it was resprayed, even at the cost of turning the team. By the employment of a mechanic the pumps were kept so adjusted as to do satisfactory work.

The results were beyond expectation. When the winter work was begun the new double-hose arrangement by which the oil and water are kept separate until the nozzle is reached was employed. Instead of producing a mechanical mixture, pure oil and pure water were alternately discharged. On one morning in trying to start five pumps with these attachments a number of trees were sprayed with pure kerosene, resulting in the death of 40. The new style attachment was discarded, and no more injury was done save possibly the death of about 50 other trees which may be attributed to the combined effect of the scale and the treatment. The trees bloomed and leaved out normally, and are now bearing a magnificent crop of fruit.

The scale was as nearly eradicated as the writer believes possible with any treatment. During the course of spring and summer until June 17, when the last observations were made, the writer visited the orchard three times and carefully examined several hundred trees both in the kerosene and crude oil blocks, and found only two trees bearing live scales. These were located in one of the kerosene blocks where two applications had been made. A general inspection of the orchard on June 17 revealed no further infestation of living scales. It is understood, of course, that should every tree in the orchard be carefully examined a large number would no doubt show some living scales, but the observations have been sufficiently extensive to warrant the statement that better results can rarely be obtained with any practical treatment.

SOLUBLE ARSENIC IN ARSENICAL INSECTICIDES.

By J. K. Haywood, *Washington, D. C.*

Chief of insecticide and agricultural water laboratory, Bureau of Chemistry, U. S. Department of Agriculture.

The two insecticides to which I chiefly desire to call attention are Paris green and London purple. As is well known, Paris green is composed of copper oxid, acetic acid, and arsenious oxid, which are all combined to form copper-aceto-arsenite, in the following proportions:

	Per cent.
Copper oxid	31.29
Arsenious oxid	58.65
Acetic acid	10.06

Since this is a commercial article, small amounts of foreign matter are always present. Among these may be mentioned sodium sulphate, sand, and arsenious oxid, the last of which is not combined as it should be with the other two constituents, but is present in the free state. It is this arsenic which is generally supposed to scorch foliage when applied in too large amounts.

In California, and in the East generally, 4 per cent free arsenious oxid has been adopted as being the maximum amount allowable in Paris green, the free arsenic being determined by dissolving it from the Paris green by means of distilled water.

What I desire to call attention to here is that there may be three conditions giving rise to a scorching of the foliage by the use of Paris green:

(1) As I have already said, there may be a certain amount of arsenious oxid in the Paris green over and above that combined with the other constituents. This is called "free" arsenious oxid, and has until recently been considered as the only cause for the scorching of foliage by Paris green.

(2) A number of Paris greens now on the market are poorly made, and when brought in contact with water, especially water charged with carbon dioxid, readily break up in the course of a short time, arsenious oxid being set free in the process. This is true to some extent even of the best Paris greens, but the poorly made ones break up much more quickly and readily. Let us see, then, what the effect of such greens would be upon the foliage. They would, in most cases, be sprayed upon the leaves while suspended in water. The water, along with the carbon dioxid of the air, would immediately commence to set arsenious oxid free. Not only would this go on with the original water, but the rain and dew that collect upon the plant would carry the process still further, and in the case of a poorly made article there would soon be enough free arsenious oxid to seriously scorch the foliage. Of course this change would go on in the case of well-made Paris greens, but so slowly that unless the climatic conditions were very adverse not enough arsenious oxid would be present at any one time to do any serious damage.

(3) It is a well-known fact that even the best Paris greens, when ground to a very fine powder and applied to the foliage, will scorch. This seems to be due to the fact that the fine grinding exposes more surface to the action of water (and water charged with carbon dioxid), and that consequently the decomposing action of the water on the Paris green is accelerated and enough free arsenious oxid soon gathers to do serious damage.

It appears, then, that there are three conditions of Paris green that may give rise to free arsenious oxid and consequent scorching, and what confronts the chemist is the discovery of a method or methods by which he can tell how much free arsenious oxid is actually present in a sample of Paris green, or how much, because of its condition, may be set free in a short length of time.

This is rather a hard problem and, from the nature of the case, only an arbitrary method can now be proposed or expected.

Manifestly it would not do to extract the sample for twenty-four hours with water since, in this length of time, even where free arsenious oxid is present as such, it does not all go into solution nor does a badly made or very fine Paris green decompose to a great extent in this length of time. It has been found by the author that it takes nearly ten days for all free arsenious oxid in Paris green to go into solution. It has also been found that badly made Paris greens are broken up enough during the course of ten days to show whether they are very unstable or not and that well-made Paris greens are not broken to a great extent in this length of time. Avery and Beans[a] have found that at the end of ten days a finely powdered article has been broken up to a great extent. It has therefore been thought best to determine the soluble arsenious oxid in Paris green by extracting 1 part with 1,000 parts of water (free from carbon dioxid) for ten days and at the end of this time determine the arsenious oxid in an aliquot portion of the filtrate. This method does not distinguish between the three causes of the soluble arsenious oxid, but it is undoubtedly true that all three are bad, although very likely not equally so. Other work done by Avery and Beans distinguishes to a certain extent between free arsenious oxid as such and the other two forms, so that at least we can say whether the soluble arsenious oxid is due to free arsenious oxid on the one hand or badly made or fine Paris greens on the other.

Since these three distinct types of soluble arsenious oxid have not been previously recognized, and since, when 4 per cent was adopted as the maximum limit of soluble arsenious oxid allowable in Paris green, a much shorter time of extraction with water was used than ten days (resulting in much lower figures for soluble arsenious oxid), it appears to the author that work along this line is needed badly, work that will determine the maximum percentage of soluble arsenious oxid that can be present in Paris green without scorching in each of the three forms, or as many of these forms as our present chemical methods will enable us to recognize.

The Bureau of Chemistry, U. S. Department of Agriculture, in collaboration with the Division of Entomology, is now carrying on preliminary work of this character, but in order to make the work a success each of the States will have to take it up, it being well known that climatic conditions markedly influence the amount of free arsenious oxid that a plant can stand. I therefore lay this matter before you with the hope that entomologists from the various States may be interested enough in the work to collaborate with us during the coming spring. The Department will prepare all samples and send them out and the various entomologists will do the spraying, for which full credit will be given in each case.

The second class of insecticides to which your attention is directed are the London purples. These are prepared by boiling an analine dye residue containing arsenic with lime. Up to a very recent date

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[a] Jour. Amer. Chem. Soc., Vol. XXIII, No. 2.

London purple was supposed to consist of an organic dye residue and calcium arsenite, but work which the author has carried on shows that it consists of an organic dye residue, calcium arsenite, and calcium arsenate.

While the relative quantities of the two last-mentioned substances vary a great deal, the total amount of metallic arsenic is nearly the same in all samples examined.

According to the old way of examining London purple, a portion was extracted with water and the soluble arsenious oxid determined in the solution. Where this was low the sample was passed as good and was used in spraying. Since it has been found, however, that arsenic oxid is also present, this must also be determined in the soluble portion. Proceeding in this way, it was found that whenever the soluble arsenious oxid was low the soluble arsenic oxid was high, and vice versa, so that in every sample examined the total amount of arsenic going into solution was very high, much higher, in fact, than the maximum limit of 4 per cent that has been previously recognized. Following are examples of three representative samples:

	Soluble arsenious oxid.	Soluble arsenic oxid.
	Per cent.	*Per cent.*
1	2.43	15.81
2	13.49	7.12
3	1.44	19.56

It is a well-known fact that although London purple has gone out of use to a great extent now because of its scorching the foliage, it has been used and is used in many cases with excellent results. The only conclusion we can come to from the above facts is that many plants, under certain conditions at any rate, can stand a vast amount more of soluble arsenic than has been previously supposed. Of course, if this arsenic were present as the free acid it would undoubtedly kill or defoliate the tree; but its being present, as it is in London purple, as the calcium salts of arsenious and arsenic oxid evidently has a strong modifying influence.

Compounds of this class are also being studied by the Bureau of Chemistry and Division of Entomology and, just as in the case of Paris green, the cooperation of the various States is absolutely indispensable to the success of the work.

The foregoing paper by Mr. Hayward was read by the secretary of the association.

After the reading of these papers, they were opened for discussion.

Mr. Smith stated that he had taken a greater interest in these papers than in any series of papers for a long time. He thought that they covered a field that had not been satisfactorily covered before. It happened that when the lime, sulphur, and salt wash was first tried in Washington, the result as recorded by Mr. Marlatt and others was that it afforded but little protection. One or two others tried the same material and the results were equally poor. In a second bulletin from the U. S. Department of Agriculture, the chemical reactions in the wash were set forth and it was shown almost conclusively that it could not reasonably be expected to be of much value in in the moist East. A year or two ago one or two Jerseymen tried the wash on rather badly infested peach orchards, and the results seemed to be very good. During the past winter a number of other New Jersey fruit growers had successfully tried the wash. He called attention to a point not previously mentioned, namely, that the results of recent experiments in Illinois had been remarkably successful. He thought that the experiment there was nearly a complete success, 99 per cent of the scale having been killed at the time when Dr. Forbes's bulletin had been sent to the press. Dr. Forbes examined the experiment trees before the wash was applied, and discovered that when the winter had set in fully 50 per cent of the scale was dead. This fact was to be considered in estimating the amount of good done by washes. He had seen trees where no treatment had been made where 75 per cent of the scale was dead in the early spring. Any sort of wash put on during the winter, if no previous count had been made, would be credited with killing 75 to 80 per cent of the scale, so that there will be an element of error in the statement of results unless previous examination has been made. This is a point to which Dr. Forbes gave proper attention. He was the first one, who in his records of results, took pains to take this into consideration and published the count. Mr. Smith stated that there are a number of localities in New Jersey where the lime, sulphur, and salt wash has been used on peach, pear, and apple. Very few plums had been treated and more peach than any other fruit. One of these places is in the vicinity of Mount Holly; a second is nearer to Camden; the third is in the vicinity of Heightstown. They were all in one general section of the State, and something like 70,000 or 80,000 trees were treated on a commercial scale. The formula used was almost universally 50–50–50 to 150 gallons of water. The proportion of the sulphur to the water was nearly the same in all of the mixtures. The preparation was very thorough, some steaming and some boiling direct. He had visited almost every one of the sprayed orchards, and the last visit had been only two or three days ago. The majority of the trees were large. The work was done with barrel sprayers or with power sprayers on carts. Where the work was done on small trees that were not badly infested the results were very good. A great many trees seemed to have few or no living scale on them. In one orchard, although the breeding season was already well advanced, there was only a single tree upon which any larvæ were found, but there were quite a number of trees where living females occurred. The adjoining orchards showed that the scale was in full progress of breeding. Wherever very badly infested orchards were found it was observed that the wash had been least effective; that is, it was not successful in killing any large percentage of the scales. A tree incrusted with scales, still coated with the spray, would, on examination, be found to contain great numbers of the living insects underneath. So where the material was most needed it was least effective. On adjacent trees on which the scales were scattering the effect of the wash was very good. The wash does not penetrate nearly as well as the oil or soap mixture, and it does not spread at all. Where it hits it sticks and seems effective, but it does not have much penetrating power. It is, furthermore, difficult to get it on the smaller twigs. This is an important point with apple trees, and unless the twig is hit the insects will not be killed. Farmers generally agree that it takes 3 gallons of the lime-sulphur-salt wash to do the work of 1 gallon of oil mixture. In New Jersey a gallon of the wash was stated to cost for material about 1½ cents. This did not include the cost of mixing and the incidental cost of boiling and time of the laborer. In practice a sufficient amount of the wash to go as far as 1 gallon of oil would cost 4½ cents. One orchardist used both, and prefers the oil because of its convenience. The farmers in New Jersey used the undiluted oil more than the emulsion. Some had tried to make a soap emulsion, but had lost all interest in the mixture. He thought there was no doubt that, particularly in peach orchards, the lime-sulphur-salt wash could be satisfactorily used. The oil was hard on peach trees, unless sprayed on with a very fine nozzle, and very carefully.

Mr. Marlatt said that he desired to join Dr. Smith in his hearty appreciation of the value of the papers presented. The experiments and work reported were of great interest on account of their considerable extent. He believed that the results of the work reported by Professor Scott and others in the South indicate that the question of how to practically control the San Jose scale has been solved. He congratulated the authors of the papers very heartily on the results obtained by them. He referred, in brief, to his personal experience with the use of oil on trees, including the orange in California.

In reference to the early experiments of the Department in the East with the lime, sulphur, and salt wash, he stated that the work was conducted by Mr. Coquillett and himself, and was carried out in the most practical way, Mr. Coquillett having recently come from California, and being thoroughly familiar with methods there employed. A careful record of weather conditions was kept subsequent to the treatment. The percentage of scales killed was noted from time to time throughout the winter and the following spring, and in the case of no tree, even where the wash had been used at considerably greater strength than recommended in California, were results of any very great value seen. A full record of these experiments is given in Bulletin No. 3 (new series) of the Division of Entomology. It was noted at the time of these tests that a considerable percentage of the San Jose scale died during the winter where no treatment had been given, usually as much as 40 or 50 per cent perishing. Therefore, the treatment was considered to be of no value unless a notably greater percentage of scales were killed than would have succumbed normally. Both the California wash and the Oregon wash were tested at normal and double strengths. With the knowledge that the applications, as reported above, were more carefully made than would be ordinarily the case with farmers and fruit growers, the results were so poor that this wash was not recommended for use in the East. The reports of the success following its use in California, in view of these results, were not easily understood, and at first it was thought they might be founded on error, but the speaker had subsequently the opportunity to visit California and personally inspect results on the Pacific slope, and he found that there was no possibility of questioning the efficiency of the wash in that region. The explanation was evidently in the differences in climate between the Atlantic and Pacific coasts. In the former, the wash being applied in winter, remained on the trees unaffected by rains or moist weather, often for several months, the wash being applied after the rainy season, in late winter. In the East, on the other hand, the wash is usually subjected to washing rains within a few days after application, and it was believed that this explained the difference in results. Later on he had again taken up the investigation of the lime, sulphur, and salt wash in cooperation with the Bureau of Chemistry of the Department of Agriculture. The results of these experiments are given in Bulletin No. 31 (new series) of the Division of Entomology. The wash had been prepared with the use of a steam plant and after the most approved California methods, and was applied almost boiling hot to scale-infested trees. In this instance it killed every scale on the trees, the application being thoroughly effective. The reason for this seemed to be that the weather conditions following the experiment were very favorable. The heat of the wash does not explain the death of the scales because, however hot may be the liquid when broken up into a thin spray, it is cool a few inches distant from the nozzle. Mr. Marlatt further stated that he still believed that, as a rule, the same difference would be experienced between the East and West on account of the greater rainfall of the former section, and that the wash was on this footing, namely, that if weather conditions are favorable it will be efficient; otherwise measurably useless. The cost of the application is very slight, especially if it is prepared in hogsheads with steam. He said that the surprising results reached by Dr. Forbes were difficult of explanation, especially as rains or artificial washing of sprayed plants did not seem to affect the efficiency in the case of his tests. He believed that the result of Dr. Forbes's work made it necessary for experiment station entomologists everywhere to give the matter again a thorough test in the East, and he proposed that the Division of Entomology in Washington undertake experiments next winter with the wash. The chemical analyses which had been made by the Bureau of Chemistry indicated that while the wash would remain in evidence as a white coating on the trees for a long time in spite of heavy rains, most of the beneficial elements would soon be leached out. As to the formula for the wash, he stated that it varied with almost every person who experimented with it. The chemical reaction between the sulphur and lime was well known, and if too much lime was used, as was ordinarily the case, it simply remained free lime in the mixture and added to the coating on the trees. The general reactions with the lime, sulphur, and salt were noted in the chemist's report in the publication cited above.

Referring to the records of percentage of scales killed, he said that in making these estimates it was necessary to take into account the transformations of the scale insects, and that the great majority of the San Jose scales on a tree in late winter would be the male scales. On trees in the orchard in the Department of Agriculture, perhaps 97 per cent of the living scales on the trees in April of this year were of the male sex. These hatch out very early in the spring, and when they are gone at once give the appearance of death to a very large percentage of the scales on the trees. He stated also that, where female scales from any cause have not been fertilized by males, their period of life is very greatly increased, so that it is sometimes possible to find overwintered female scales on trees in midsummer. An examination he had made of some of these had indicated that they had not been fertilized and were not developing eggs, and they ultimately perished without having reproduced. It thus might happen that all the male scales would be killed, and the female scales would remain unfertilized, though alive, and would perish before a succeeding brood of males would be produced.

In California the difficulty of spraying large trees was largely reduced by having them pruned back vigorously, and it was generally believed that the benefit in the ease of gathering the fruit and the superior quality of the fruit coming from this vigorous pruning offset the cost and trouble of spraying, so that the San Jose scale instead of causing a loss had really worked advantageously to the fruit grower. This applied especially to the peach and prune.

Mr. Marlatt added that Dr. Forbes's experiments had had special relation to the subsequent action of washing rains, and that they seemed to show that such rains had no effect on the benefit coming from the wash. Furthermore, Dr. Forbes had actually thoroughly washed with water trees which had been treated, and again the action of the insecticide had not been decreased. It was on this account that Professor Forbes's experiments were of so great importance and opened the whole subject for renewed investigation, indicating, as they seemed to do, that the wash could be used in regions where rains are frequent as well as in dry climates like those of the Pacific coast.

Mr. Smith suggested that perhaps a large number of small trees had been used in the experiment.

Mr. Felt in this connection called the attention of the association to the influence of rains on the wash in New York State and considered it to be apparently what would be expected. He had examined some treated limbs and found the live female scales quite abundant. He was informed that the application had been followed by quite a little rain, and in his own experiments he was in hopes that some would fall, and the rain came immediately after, thus furnishing him exactly what he desired. The entire experimental orchard was sprayed, and it seemed very doubtful if the work could be completed before the rain came, but the work was finally finished. The rain continued for about three days, so that he considered it a very severe test. The treated trees were looked over at different intervals until about ten days ago, and of the trees treated with the wash some at least contained living female scales, although most of them were not very badly infested. The most of the living insects were, as Dr. Smith had stated, under masses of scales. The wash did not penetrate into the masses, and it was his experience that where the bark was rough the insects were not seriously affected. He thought that when the wash was applied the trees should be dry.

Mr. Smith, in reply to a question, said that one of the farmers whom he had advised to use the kerosene emulsion had used 5 pounds of soap instead of one-half pound, as ordinarily recommended. The resulting mixture was very satisfactory, but it was a fatal one. The emulsion was diluted 10 times and applied to the trees just as the leaves were dropping, and the results were very disastrous.

Mr. Scott stated that in his paper he had not included his experiments with summer washes. He explained in regard to crude oil in soap emulsions that as low as 10 per cent of oil very badly damaged trees in foliage, whereas the 10 per cent in mechanical mixture did very little damage; he had found wherever the soap was used in crude oil or kerosene the results were more disastrous than in case of the mechanical mixture. Experiments had been made last winter where soap had been used in connection with the oils to determine whether or not an excess of soap would have any beneficial effects in the kerosene and petroleum emulsions. The soap was used according to the regular formula and from that up to as high as 2 pounds of soap to the gallon of water, so that there was a large excess of soap. The results were not any better than those where the usual amount had been used. In fact, any amount of soap in excess of that necessary to make a proper emulsion he had found valueless. On the other hand, in the summer tests the soap in the emulsions was more injurious than the oils. He stated that he had found quite 40 per cent of scale dying during winter without any treatment, and he took this fact into consideration in making up the results. Frequent communications had been received from orchardists saying that the cold weather had killed the scale. Mr. Scott considered that careful estimates should be made of the scales that die without treatment in determining the percentage killed by the application of washes.

Mr. Quaintance asked if anyone had had any experience with the lime, salt, and sulphur wash in the fall, and how early it had been used. In Maryland the fall weather is usually more favorable for spraying work than the spring.

Mr. Sanderson remarked that while he had done no work with the wash himself, several orchardists of Delaware had used it, made up according to the standard formula. He had examined a badly infested orchard about ten days ago that had been thoroughly treated with the wash, and the trees at that time were still quite thoroughly coated. A careful examination of infested twigs showed that from 50 to 75 per cent of the adult females were alive. He had had slight experience in the use of crude oil on trees in foliage. Fifteen or 20 plum trees had been sprayed thoroughly, covering the leaves, but no damage had resulted, and the scales had been very largely killed.

Mr. Quaintance desired to know of Mr. Sanderson what the weather conditions were in connection with the use of the lime, salt, and sulphur wash in Delaware, to which Mr. Sanderson replied that he had no record of this. It was his experience that the scale was more readily killed in the Southern sections than in Northern sections. He had tried kerosene emulsion of the ordinary strength, diluted 10 times, and had noted very little change in results from its use.

Mr. Marlatt remarked, in reference to Mr. Scott's experience with emulsion, that the emulsion is often more dangerous to trees than pure oil—that is, if it is put on in a very strong mixture—for the reason that a thick emulsion wash adheres to the bark, and much more oil is held on a given area with the emulsion than would be in a thin pure-oil spray.

Mr. Smith stated that in the soap emulsion the oil is held longer in contact with the trees. The soap holds the oil, prevents its evaporation, and it is thus held longer in position than when put on pure.

He had found that pure oil could be used with greater safety than the soap emulsion.

Mr. Scott called attention to what had been said in regard to the scale being more readily killed in the South than in Northern latitudes and thought this must be correct, because Professor Lowe had recorded in his bulletin that he used a strength of 40 per cent crude oil, the highest ever used, but it was effective against the scale, and that 25 per cent was absolutely worthless.

Mr. Felt replied that in the vicinity of Albany Mr. Lowe's results did not hold good, and that 25 per cent would kill the scales if they were hit.

Mr. Scott stated that 25 per cent crude oil in Georgia would practically kill every scale with which it came in contact. It had been thoroughly demonstrated with two or three years' experience that 20 per cent is all that is necessary. Even 15 per cent crude oil gave good results against the scale and he did not consider it safe to use more than 25 per cent. He was glad that Mr. Marlatt had said what he did concerning the extensiveness of his experiments, as he rather feared that he might be criticised for using such a large number of trees. The Department furnished the oil and the owner furnished the labor, trees, and risk. He stated that there was one orchard in Georgia of 150,000 trees that had been sprayed with the crude oil last winter and another of 200,000, and that, unless one were pretty sure of results, it was too risky to make recommendations. Mr. Scott further stated, in response to an inquiry from Mr. Marlatt, that the crude oil in mechanical mixture was his preference of the different lines of treatment, provided that pumps could be had that would accurately discharge the proper amount of oil. Otherwise the soap emulsion is preferable.

Mr. Smith inquired if the pumps used were of the new model, to which Mr. Scott replied that they were of the latest model, that they had been used one day with the oil and water kept separate, but that it became necessary to discard these connections and change to the old style of pump. His reason for preferring the emulsion was because it could be depended upon almost absolutely, while with the mechanical mixture the pumps gave varying results. One lead of the hose might be discharging a greater percentage of oil than the other.

Mr. Scott further stated that he had used the pure crude petroleum in an experimental way the winter before. Twelve trees had been sprayed, of which number 6 were killed. He considered pure crude petroleum quite unsafe, but thought that it could be used as high as 50 per cent if applied vary carefully and very lightly.

Mr. Burgess stated that from the previous discussion it appeared that it must be much more difficult to kill the scale North than farther South. In northern Ohio it was a very difficult matter to kill the scale without injuring the trees. He made some tests with the kero-water pump which were not very satisfactory—that is, the pump would not throw a given percentage constantly—and in the experiments made recently a motor-spray pump had been used. This pump was used largely in the northern section of Ohio and very few trees were injured, but the scale was not held in check. This year the trees were sprayed more thoroughly. Some were over sprayed, and, as a result, at the present time, he estimated that there were probably 10,000 dead trees in that section. This is the principal fruit-growing district, and such a loss means considerable to the growers. The men who applied the spray in this section were growers who have had a great deal of experience in spraying, and certainly would be as careful as hired men. Mr. Burgess related one instance where peach trees were seriously injured by using 25 per cent mechanical mixture of crude petroleum, and called attention to a recent New York bulletin, in which it was stated, from results there indicated, that peach trees sprayed late in the spring were less liable to injury than if sprayed earlier in the season. His experience in northern Ohio was almost opposite. The trees sprayed late in the spring had been injured more than those sprayed earlier, as in January or somewhat later. The fact that so many trees had been killed and injured this year made the scale problem a serious one. The growers were enthusiastic in using the crude petroleum and thought they had found a substance which could be used safely to kill the scale. It seems now that much more care will have to be used in its application, or a safer remedy devised. A good many growers last year thought they had not sprayed sufficiently and this year attempted to spray the trees more thoroughly. On peach trees, a very careful application of crude oil must be made. Attention was called to another point in this connection—that the effect of spraying was different in different years. Some growers had sprayed thoroughly last year and no injury had resulted to their trees. The same trees had been sprayed this year with considerable injury. The results did not seem to show, one year with another, what results might be expected after spraying.

Mr. Quaintance remarked that according to his experience in Maryland there was considerable variation in the effect of both kerosene and crude petroleum in different parts of the State. In western Maryland the kerosene treatment, on the whole, had been found quite satisfactory, and 20 per cent kerosene in mechanical mixture was very largely used. On the Eastern Shore, however, the use of kerosene or crude petroleum, even under the most favorable weather conditions, had been reported in numerous cases as giving fatal results to the trees: On the whole, for this territory he was inclined to recommend the use of whale-oil soap. He stated that he had met with much difficulty in the use of the kero-water pump, from the fact that the percentage of oil varied with nearly every pump, and even the same pump at different times. Many of the orchards in the State were managed by tenants. Under such conditions it was difficult to get the intelligent cooperation necessary to secure proper results from the use of kerosene or crude petroleum.

Mr. Smith suggested that we have to do with a problem for a plant physiologist. The records given were so contradictory that it seemed to him to be due somewhat to the condition of the plant. He suggested that the matter be investigated from this point of view and that it be referred to some plant physiologist. He considered that the experiments reported proved two or three points fairly well—that the oil would kill the insect under the scale if it comes in contact with it, and that a quantity of oil sufficient to touch the insect is all that is necessary. The question of its effect on the tree is an important one. It is not fair to take the results from one part of the country and make them the basis for recommendations for another part. The results which he had obtained in New Jersey had been duplicated time and again in his State. He had never yet succeeded in killing a peach tree with crude petroleum, but had crippled some. He knew of other persons who had killed trees. He did not understand this difference, nor why the scale is more hardy in the North than in the South.

Mr. Holland stated that crude petroleum, as generally supplied, was a most puzzling mixture. He had at the university something like 150 samples of oil ranging from white to some of high specific gravity, and thought that a chemical analysis would probably eliminate some of the trouble. He stated that he considered Professor Phillips probably best qualified to make an analysis of crude oil, and thought the work one of the most complicated problems in chemistry. He thought that if the fruit growers could get the run of certain wells the difficulty might be largely obviated.

Mr. Felt remarked that he had gotten very good results from wells in certain sections, but he was very much puzzled how such contradictory results could have been secured from New York State. The results published by Professor Lowe were not at all like those which he had obtained.

Mr. Burgess agreed that the assistance of a chemist and a plant physiologist were urgently needed.

Mr. Smith stated that the question of determining the composition of crude petroleum and of getting an oil of as uniform a grade as possible for spray purposes was recognized by him as a serious one. At his suggestion the Standard Oil Company, from which he had been securing material, had applied the term "insecticide oil" to a particular grade which they sent out under that name. Oil simply ordered as insecticide oil was of this grade, and had been very uniform, so far as he knew. This oil was and had been used in New Jersey with considerable safety. He fully realized the value of the point that Dr. Holland made; he had tried to get some one to make the analysis; but no chemist seemed to want to touch the problem.

Mr. Hopkins mentioned the fact that the subject of vaseline had been under investigation by the chemists of the West Virginia station. They had taken vaseline and mixed it with kerosene, and experiments had been carried on with it. He thought Mr. Rumsey might be able to give something of interest about this work.

Mr. Rumsey replied that he considered it premature to make any statements concerning this work, as it had not been in progress very long and he had made but two inspections of the trees since the application of the oil.

Mr. Quaintance stated that in his opinion the entomologists would have to ask for help in connection with determining the cause of the variation in results from the use of oils in various parts of the eastern United States as a treatment for the San Jose scale. He considered it a very important matter and thought that the question should be straightened out and put on a scientific basis. Until this was done, the danger of injury to trees sprayed with the mineral oils would probably not be removed. He suggested that the Secretary of Agriculture be petitioned to detail an entomologist, a plant physiologist, and a chemist to make the investigation of this problem a leading line of work.

Mr. Scott stated that he had asked for prices of the Standard Oil Company on their insecticide oil, and their price, with freight added, would make it cost something like 15 or 16 cents per gallon delivered in Georgia. He had corresponded with several oil companies and found that a high-grade oil could be bought and delivered at Savannah for 8½ cents in carload lots. He had first obtained a barrel of the oil and tested it and found it averaged about 43½° Baumé. It had never run under 43° in any of the barrels that were tested. Twenty thousand gallons had been secured for last winter's work. One company proposed to put up crude-oil tanks in orchard sections of the State and supply the crude oil to the orchardist in the same manner kerosene is supplied to the merchants. He asked Dr. Smith what was the specific gravity of the oil that had been used in New Jersey.

Mr. Smith replied that this usually ran between 43° and 44°, but never ran under 43° in any of the samples which he had seen. In every section where crude oil is used, the commissioner has a hydrometer and tests the oil, so that it is thus possible to keep pretty close record of the oils in use in the State.

Mr. Sanderson suggested that the committee on resolutions take up the matter of petitioning the Secretary of Agriculture to detail investigators from the Department to help solve the problem.

Mr. Hopkins suggested that best results were likely to come from cooperative experiments.

The society then adjourned to reassemble at 10 o'clock Saturday morning.

MORNING SESSION, SATURDAY, JUNE 28, 1902.

After calling the meeting to order, the president announced that first on the programme were three papers by Mr. Marlatt:

RÉSUMÉ OF THE SEARCH FOR THE NATIVE HOME OF THE SAN JOSE SCALE IN JAPAN AND CHINA.

By C. L. Marlatt, *Washington, D. C.*

A preliminary report was read before the last meeting of this Association detailing the results of a three months'[a] investigation by the writer of the San Jose scale in central and southern Japan. The present report relates to the investigations in Japan subsequent to July 1, 1901, and the explorations in the autumn of the same year in China. This report is merely a brief summary and is preliminary to an extended account of the trip which will appear elsewhere.

In the discussion which followed the reading by Dr. Howard of the writer's preliminary paper in Denver last year, a misapprehension as to the extent and thoroughness of the investigation was evident on the part of several speakers who seemed to feel that the work had been done chiefly along the railroads, and that, therefore, the interior of Japan was not being explored; and further, that this interior region, if carefully investigated, might throw an entirely different light on the subject and perhaps would demonstrate that the interior and the more inaccessible regions of Japan were the ones from which the San Jose scale had come and in which it is native. Some of the speakers, notably Dr. Howard, felt sure that no opportunities for investigation or localities would be neglected by the writer, but several of the speakers took readily to the suggestion that the exploration of the interior, away from the railroad lines, which it was supposed had not been made, would be very desirable. The fact apparently was overlooked by all of those taking this view that railroads are a modern institution in Japan, and that instead of the older settlements following the lines of such roads in Japan, this is purely accidental. In point of fact the railroads strike through the country over the most available routes and often plunge through the heart of interior Japan, traversing the mountain wilds as well as the cultivated valleys, and are more apt to reach out-of-the-way districts than the older highways and roads. Furthermore, many of these lines have only just been completed, and in my trip southward the line which now runs from one end of the main island to the other was not finished, and a considerable portion of the trip was made by boat in consequence.

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[a] April, May, and June, 1901.

Aside, however, from the subject of working along the railroads, which in Japan has not the same significance at all that it would in a new country like America, I may call attention to the fact that very many of my trips were across islands and into the interior far from any railroad lines and even where foreigners had never before penetrated, so that I had the novel experience on several occasions of being the first foreigner seen. I feel satisfied that my explorations covered Japan sufficiently well to enable me to form a final and correct judgment on the San Jose scale problem in that country. The explored region included the five main islands of Japan, from the northermost island, Hokkaido, to the southernmost, Kyushu, and also the islands of Awaji and Shikoku, rarely visited by foreigners, lying to the south of the main island, both of which I crossed by jinrikisha, and, in the case of the larger one, Shikoku, surmounting a high mountain range.

In my former report, which covered one-half of the time spent in Japan, or some three months, and related to the investigation of some thirty-five of the southern provinces, or districts, it was stated that there remained to be explored the northern half of the main island (Hondo) and the northern island of Hokkaido; and, furthermore, that this northern region had a special interest on account of its containing extensive apple orchards, which are developed on very much the same lines as in America.

The heat and moisture of midsummer in Japan renders life unendurable in the low countries, and, tiding over this period, some weeks were spent in the mountain regions of central Japan, dividing the time between Niko, Chuzenji, and Yumoto, places having elevations respectively of 2,000, 4,500, and 5,000 feet. From these different places side excursions were made. The whole region covered is a mountainous one and of wild forest areas, the cultivated portion being of small amount—mere garden patches in the villages. In this region also are great imperial domains or forest reserves, and in one of these is a summer palace of the imperial family. Over three weeks were spent in these mountains and a careful study was made of the district from an entomological standpoint. Insects of all kinds were very few in numbers, and scale insects were practically wanting. The fruit trees and flowering trees grown in the private yards and small gardens, comprising such plants as mulberry, cherry, plum, and peach, were often examined, but not a single scale insect was discovered. The absence of such insects is doubtless to be accounted for by the climate. In this elevated region it is cool in summer and very cold in winter, and during the summer months the rainy season normal to the period is much intensified by the mountains catching the rain-clouds, so that downpours are of daily occurrence and the humidity is unusually great. As a result the trunks and limbs of trees are covered with lichens, moss, and fungi. In the woods, and especially on the elevated mountain plains this side of Yumoto, were found a species of wild apple, probably a Cratægus, having a fruit varying from an eighth to a quarter of an inch in diameter. No means of determining the species were available. The San Jose scale had either never been introduced into this region or had failed to get a foothold, and it certainly occurred on none of the trees planted in temple and private gardens nor on the wild plants on which it might have been expected, as, for example, this Cratægus.

Early in August the writer left this region for an extended trip through the northern provinces, the distance being covered partly by rail and partly by boat, and side excursions were made into the interior by jinrikishas. Either going or returning, stops of sufficient length to investigate the adjacent regions were made at all the principal towns, and from several of these lateral excursions were made. In the north island the exploration covered the principal town on the southern shore, Hakodate, and a trip across the center of the island from the east to the west side, with a stop of some four or five days in the capital town of Sapporo.

Over a large region in the northern end of the main island of Japan (Hondo) Japanese settlement and complete occupation has only taken place within modern times, and there are still large areas in native grass land, the rolling nature of the country in portions of this region recalling somewhat our own prairies of the Middle West. Throughout this section and in the island of Hokkaido, which is also new to Japanese settlement, the agricultural conditions and methods are totally different from those of the older settled portions of Japan. Horticulture especially is here modeled more directly after the American pattern, and in the north island American methods of farming as well as of fruit raising are closely copied. This is largely due to the work of the agricultural college at Sapporo, where for many years were American instructors and a general introduction of American methods. This institution is continued now under Japanese direction and with a Japanese faculty, but the whole region, both in its fruit raising and general farming, reminds one very strongly of America.

The chief interest in this region comes from the fact that in the northern provinces of Hondo and in the settled portions of Hokkaido fruit raising has been developed on a scale not equaled elsewhere in Japan. The fruit raised is chiefly the apple, and the products of this region supply Japan, and to a certain extent, also, the markets of eastern Asia. The apple is grown in all this region very much as it is with us, in large orchards; the varieties are our varieties, and have been imported from America, very few European varieties having been introduced.

The apple industry in Japan, as indicated in my former communication, is of recent origin, say within the last thirty years; most of the stock has been obtained from California, and, as a rule, was undoubtedly more or less infested with San Jose scale when received. Throughout this region the San Jose scale was found scatteringly in all orchards and in all gardens. In Aomori and vicinity it was doing no very great damage in any of the orchards, but in some of the small gardens, and especially in one or two neglected ones in the city of Aomori, it was as abundant on particular trees as it often is in America. At the first investigation no evidence of parasitism was seen, but from later collections two of the parasites which attack this scale insect in America were reared in great numbers from infested branches collected in Aomori. These, as determined by Dr. Howard, are *Aphelinus fuscipennis* How. and *Aspidiotiphagus citrinus* (Craw.), the latter being the more numerous.

The Asiatic ladybird (*Chilocorus similis*) was found throughout this northern region of Japan, and evidently was an efficient means in keeping the scale in check. In certain gardens in the city where the scale was very abundant the infestation was evidently of recent beginning, a tree here and there only being very scaly, and in some instances the ladybird enemy had not yet come upon the infested plants. In other places in the city the ladybird was found in numbers, and a score were collected and put in a tight wooden box with some scale-infested twigs to determine how long the beetles could be kept safely under such conditions, as a preliminary test before attempting to ship them to America.

On the return trip to Aomori some side excursions were made by rail and jinrikisha to orchard regions toward the west coast of the island in company with Mr. Hori and some of the horticultural officers of the province. Wherever we went was found a general infestation by the San Jose scale in orchards and gardens, the scale occurring normally very scatteringly, and not at all in especially injurious numbers. Everywhere also was seen the same evidence of the scale being kept in check by parasitism by the Chalcidids which attack it in America, and especially by the predatory Chilocorus.

In the northern island the points especially investigated were Hakodate and Sapporo, the latter town being the capital city and, as already indicated, the seat of the agricultural college and experiment station and the center of modern agricultural and horticultural methods. The conditions, so far as scale insects were concerned, were practically the same at both of these places, and at one or two other places where more limited investigations were made, as, for example, at Mororan and Otaru.

The island of Hokkaido is even more wild and unsettled than the northern extremity of Hondo, and in fact, during the last thirty or forty years only has there been much effort on the part of the Japanese to settle this large island and bring it under agricultural subjection. The native Aino race, with which the Japanese have been pursuing a guerrilla warfare for the last two thousand years, has now practically disappeared, and there being no obstacle to settlement, the Japanese are swarming in. Approaching Sapporo, the country becomes more settled, and many apple and pear orchards line the railway. A very careful investigation was made, covering several days, of the region about Sapporo, the studies being assisted by the various officers of the college, notably the botanist, forester, and horticulturist, and also by Mr. Hori, who was at one time a student at this institution, and who had joined me at Aomori for my northern trip. The orchards throughout this region could be given a practically clean bill of health so far as insects are concerned. The San Jose scale had practically died out, never having apparently amounted to anything here, and the only evidences of it were a few old dead scales. Nearly all the apple trees showed slight infestation by the oyster-shell bark louse, which the Japanese seem to have imported from America along with their original invoices of nursery stock. This scale insect also seemed to be having difficulty in maintaining itself and occurred in very limited numbers, those found being, as a rule, dead—living individuals being found only in protected cracks and crevices in the bark. The cherry scale (*Diaspis pentagona*) was very rare or practically absent, very few single examples being found on cherry trees. The orchards included plum, peach, and cherry, as well as apple and pear. The scale-feeding ladybird (*Chilocorus similis*) was in evidence scatteringly everywhere feeding upon Mytilaspis, this being the only scale insect which remained to furnish it any food. The investigation covered a number of private orchards, the orchards belonging to the agricultural college, and the parks and grounds in the city.

On the return to Tokyo from northern Japan many places were stopped at which need not be specifically noted, the conditions not being essentially new. Mito, however, a city two or three hours by rail northwest of Tokyo, deserves mention. It is the site of some very wonderful old gardens or orchards of plum trees grown not for fruit, but for the bloom. The famous orchard of this place surrounds one of the old Daimyo residences, and for many years has been a pilgrimage place for the people of Tokyo and that part of Japan in the flowering season in early spring. These old orchard trees, a hundred years old or more, covered with lichens, did not present any infestation from scale insects whatever; not a sign of the San Jose scale could be found on them. In fact, I found no scale insect in this region except a very few dead *Diaspis pentagona* on cherry.

After returning to Tokyo the orchards between Tokyo and Yokohama, which had been visited early in the year and found to be infested with San Jose scale, were again inspected. A few of the trees had been subjected to some treatment during the summer, evidently with soap, and most of the scale insects had been killed either by the soapy treatment or by ladybird enemies or parasites.

Before leaving Japan opportunity was afforded to explore another interior mountain district, viz, the great mountain plateau known as the Hakone region, and a week was spent going by jinrikisha and chair and on foot over these volcanic mountains. The native settlements are largely about Hot Springs, which have become famous as Japanese and foreign health resorts. No evidence whatever of the San Jose scale was found throughout this region, and the scale insects collected were few in amount and variety. In all this region there were old cherry trees and pear trees in house yards, but no orchard plantings of any amount.

It is impossible in this summary to give the detailed facts on which the decision as to the non-origin of the San Jose scale in Japan is based. Nevertheless, perhaps enough has been said to give a fair idea of the prevalent conditions. In a general way, it may be stated that wherever the San Jose scale was found in Japan the evidence was very plain that it had been brought in recently on young nursery stock. Very often in south Japan, where the introduction of new stock is of recent beginning, the San Jose scale is still confined to the introduced stock, or has spread very slightly to the old native trees, notably the native Japanese pear. In no case was the San Jose scale found on these native trees where there was not ample opportunity for its having come to them from new stock. In north Japan the apple industry is from twenty to thirty years' standing, and is entirely new to Japan, as already indicated, the stock having practically all come from California. Furthermore, the chief sources of nursery supplies in Japan are three establishments, located one near Kobe, another near Yokohama, and the third near Tokyo. Two of these I investigated personally and found to be infested with San Jose scale. The infestation was on the nursery trees, and also on older trees left in the general disposal of stock. In nearly every case in south Japan where the San Jose scale was found it was on stock obtained from one or other of these three nurseries, and the origin of the scale was perfectly plain. In northern Japan the introduction of foreign trees twenty-five or thirty years ago has given this scale a much wider and more general range, but even here wherever you get away from young orchards and new plantings the scale disappears. That, therefore, the San Jose scale came to Japan on American stock, and is a new enemy there of fruit trees, can not be questioned.

The Japanese are extraordinarily ambitious to equal other nations in all lines of productive activity as well as in social and political life, and hence one finds in going over the Empire an astonishing number of places where limited experiments with American fruits are being carried on in private gardens and the like, and this fact accounts for the wide dissemination of the San Jose scale throughout central and southern Japan, where fruit raising, especially of the deciduous sort, is insignificant.

It was noted also that in the more remote islands where such introductions had been little if at all made, and in districts where new stock had not penetrated, there was no San Jose scale on old native trees. Furthermore, the interior mountain regions which some have thought might be the original home of the scale are entirely free from this insect, save in rare places where it occurs on recently introduced stock.

The belief also that the absence of the scale, or its being not much in evidence is due to a natural resistance of the native fruits is without foundation. The native pear trees, when the scale is brought to them by new stock, are subject to the infestation quite as much as the foreign stock. In the case of old gnarly trees of half a century or more standing the chance of great infestation is, of course, less, as it would be under the same circumstances with the old trees in America. But young native stock seems to be just as subject to attack as foreign varieties. There is an immunity, however, in the case of the Japanese peach, but this is not complete, and is to be explained by the very rough bark developed by this tree, especially in the central and southern provinces.

Anyone studying the San Jose scale in Japan at the present time without a knowledge of the horticultural history of the country and especially its recent development, as indicated above and in my former communication, might very readily and naturally be deceived by the present distribution of this scale insect throughout the islands—as one might similarly be deceived by a study of the present conditions in America—and conclude that Japan (or America) is the native home of the scale.

Not only might the present wide distribution of the San Jose scale in Japan lead to the belief that it is there a native species, but apparent confirmation of this belief would be forthcoming in the finding, very rarely, it is true, of old native pear trees attacked by this insect with no new stock near by to account for the infestation. Two such cases were noted by the writer, and may be described to illustrate this point. Near one of the buildings of the Agricultural College at Kumomoto, in the island of Kiushu, stood an isolated old native pear tree which was somewhat infested with San Jose scale. At the moment there seemed no way of accounting for this infestation, but within a distance of not many rods was found a planting of young apple and pear trees badly infested with scale. It was learned that this stock was obtained from the infested nursery near Kobe, which has been the chief source of San Jose scale distribution in southern Japan. Undoubtedly in this case the old native tree had been infested from this new stock. Confirming this inference is the fact that in the grounds of the experiment station, a mile or two distant from the college, and where no new fruit stock had been introduced, were a number of these old native pear trees all absolutely free from this scale insect. It may be added that both the college and experiment station are of recent establishment, and the old pear trees referred to were the remains of stock growing about the old Japanese farm houses prior to the purchase of the land for the college and experimental farms. The other instance was on the island of Shikoku, just outside of the city of Takamatsu, where a single old native pear tree growing in the yard of a farm house was found infested with San Jose scale. No young orchards or new plantings immediately about these premises were observed, which, however, did not prove that there were or had been none such. But in the old Daimyo Park, attached to the city not half a mile distant, was a lot of infested peach stock from the Kobe nursery referred to above. In every other instance where the San Jose scale was found on native trees there was new stock in the immediate vicinity to account for the infestation. Of even greater significance is the fact that in the great majority of instances such old native pear trees in dooryards throughout Japan were free from the San Jose scale and yet practically always bore a few specimens, at least, of a native Parlatoria and a native Mytilaspis. If the San Jose scale were native in Japan it should also have occurred with the scale insects just named.[a]

While freeing Japan from the onus of having given the San Jose scale to the world, the investigations up to this stage left the problem unsettled as to the original home of this insect. Australia and the adjacent islands seemed to be in the same condition relative to the San Jose scale as Japan, namely, there is but little doubt that it has come into these countries on foreign stock in recent years. China remained, therefore, the only probable place of origin. In Yokohama and elsewhere I was fortunate enough to meet a number of English, American, and German residents of China who were spending the summer months in Japan, and from them I was able to get what is not given in any of the books—an idea of the fruit-growing conditions of China and the location of the principal fruit districts.

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[a] Relative to the recent introduction of the San Jose scale into Japan, it is interesting to note that Mr. Albert Koebele in 1895 spent several months in Japan, and failed absolutely to find the San Jose scale anywhere, and all of us who know Mr. Koebele will understand what this means, because no better collector of insects in general, and of scale insects in particular, than Mr. Koebele has ever lived. This is simply confirmatory evidence (if such be needed) of the recent spread of this scale insect throughout Japan.

Deciduous fruits are grown from the Shanghai region northward. The peach is practically the only fruit grown to any extent about Shanghai. The great apple district of China is the region lying back of the city of Chifu in the north. The industry here started many years ago by a missionary, Dr. Nevius, has assumed very considerable proportions and spread over quite a large province, and the output of fruit is found in the markets all over central and southern China. A brief stop only was made at Shanghai in the first instance while preparations were being made for the trip to north China, the distance between Shanghai and Tientsin necessitating a five days' ocean voyage.

At Chifu an exploration was made on horseback through the districts lying back of the city, a good many orchards being visited, and notably the original orchard planted by Dr. Nevius, and the gardens and smaller orchards immediately surrounding his residence, some little distance outside of the city. Most unfortunate for the history of the fruit development of this region and of the native fruits of this part of China is Dr. Nevius's recent death. His widow, whom I met, was unable to give me any information, except that the doctor had been very active as a horticulturist during all his long residence there (thirty years), and had been the exciting agent in the development of the fruit industry of that region. His stock had mostly been obtained from America, and American varieties of apples and pears were being grown in the province. Throughout this region I found a mild infestation with the San Jose scale, with the accompanying presence of the *Chilocorus similis*.[a]

The occurrence of the San Jose scale about Chifu was not significant, and threw no light on the subject of origin on account of the fact of importations from America of stock (doubtless much of it infested) and its dissemination over this province. The fact that the scale insect was not very troublesome in this region was, however, very significant, and this was evidently due to the general presence of the ladybird. Chalcidid parasitism was not common, and the scale was hardly abundant enough to develop much of such parasitism.

The next point examined after Chifu was Tientsin, and the region lying between this considerable city and its port town of Tonkoo, after which the trip was continued to the capital city of Pekin. Much of the region of China bordering the gulf of Pechili is perfectly level and flat, and only raised a few feet above the ocean. It is devoted to the growth of cereals, wheat, barley, and millet, and orchard plantings are practically wanting until one gets into the hill country lying to the north and west, leading up to the Great Wall of China. My personal investigations of this region were confined to the district about Pekin and between Pekin and Tonkoo. Our minister at Pekin, Mr. Conger, kindly offered to give me an escort of Chinese soldiers to explore the mountain region north of Pekin, but I was able to satisfy myself of the conditions without undertaking this trip, which at this season of the year would have been almost impossible, and, in view of the unsettled state of the country, attended with considerable risk.

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[a] *Diaspis pentagona*, previously found throughout Japan, was also widely spread in China, occurring from Pekin southward to the Malay Peninsula and into Java, exhibiting in its range a wide diversity of food plants.

The facts which I learned here of greatest interest were obtained from the examination of the markets in the city of Pekin. To explain this it should be said that Pekin is the natural center and market for all the region lying to the north and west, and the streets devoted to the sale of fruits in the Chinese city are one of the sights of Pekin. The fruit and nut products are brought into Pekin in the little two-wheeled carts, or more generally on camel-back, great caravans of heavily loaded camels and streams of carts constantly entering the city with the products of the outlying provinces. One gets, therefore, in the markets of the Chinese city the fruit products of all northern China, and can study them at ease.

The conditions under which this fruit is grown I was fortunate enough to learn from engineers, officers, and others who had explored the region in question. All of the district lying between Pekin and the Great Wall to the north and west has been very carefully explored by the military authorities, and maps which amount to local road maps of the whole country have been made. From various individuals employed in this minute survey, I learned a great deal relative to the fruit growing of the district indicated. Much fruit is grown south of the Great Wall, chiefly along the protected valleys running southward and eastward from the mountain chain which this wall dominates. These fruits are native apple, pear, and peach, and a little wild haw apple which grows all over the hills. Of these fruits I examined quantities of all except the peach (which was now out of season) in the markets of Pekin, and later at Tientsin. Throughout all this region no foreign introductions of fruits or fruit trees have ever been made, and the fruits in the market are all of the native sorts. The pears are little and hard, somewhat like the native Japanese pear in firmness, but being elongate instead of spherical. The apples are what we term crab-apples, even the largest; and the smaller ones, which are more numerously represented, are not much larger than marbles, and of a brilliant red. The haw apple grows wild over the hills in this region, and is collected and shipped by thousands of bushels to Pekin and southern ports. It is of about the size of the small crab-apple just mentioned, and also a deep red, somewhat obscured, however, by a downy pubescence. This haw apple is much esteemed by the Chinese, and our minister, Mr. Conger, assured me that he was very fond of the jelly which is prepared from it. It is the most abundant fruit seen in all the markets of North China, and is even shipped as far south as Hongkong. I examined a great many bushels of these different fruits, the red crabapples and haw apples, and throughout the market I found them all infested with a scale insect which resembled exactly the San Jose scale and was later identified as such. Perhaps one apple in a hundred would have a few of these scales about the blossom end, and about the same proportion was true of the haw apple.

In making these examinations great excitement was caused among the Chinese market people, no possible explanation occurring to them for my curious and unusual conduct in overturning their baskets of apples and pawing them over and taking out one specimen out of a hundred or two, and invariably a great crowd of Chinese, jabbering excitedly, surrounded me. Occasionally finding a man who could speak a little pigeon English, I would give the only explanation which they seemed to understand, namely, that I was picking out certain minute insects, which I showed to them and allowed them to examine through my glass, which were of exceptional value as medicine. The use of insects for medicine being common in China, this explanation at once reinstated me in the esteem of all.

The finding of the San Jose scale scattered over these fruits in the Pekin market was a very interesting discovery. The haw apple is a wild fruit growing over the hills of this section of China. The native crab is the apple which has been grown in this region from time immemorial. The occurrence of the San Jose scale on these two fruits and on the native pear also has but one explanation, namely, that in this section the scale is native. The fact of its scattering occurrence is what one would expect under the circumstances, namely, in a region where a scale has always occurred it has reached the balance with its natural enemies, so that it is rarely, if ever, injurious.

The conditions indicated in the markets of Pekin were substantiated by examinations in Pekin and in Tientsin. Pekin was an utterly destroyed city and very little of residences or gardens were left for examination. Tientsin was little injured by the war, and a good many gardens were examined. Fruit growing in this region, however, does not occur to any extent, and the gardens simply exhibited a few trees and chiefly the ornamental plants of the region, notably the Chinese flowering peach, which is grown solely for its bloom, its fruit being diminutive and not edible. This peach I found nearly everywhere scatteringly infested with the San Jose scale, and always with it the ladybird, *Chilocorus similis*. This predaceous insect seemed to sustain the same rôle throughout north China as in Japan. At Tientsin, through the courtesy of the German medical authorities, I was able to make a microscopical examination of the scale insects, and demonstrated beyond question that they are the San Jose species.

Returning later to Shanghai, after making another short stop at Chifu, I made a thorough examination of the peach-orchard district lying to the west of this city, and in these orchards I found not a trace of the San Jose scale. Later I examined several of the small Chinese nurseries and gardens in and about the city, and in one of these nurseries I found on some young stock the San Jose scale. It was dying out, however, and evidently the climate of Shanghai and southward in China is not one which the San Jose scale can successfully endure. The difficulty is probably due to the excessive heat and the accompanying great moisture of the rainy season of summer, which probably develops a fungous disease and exterminates the scale. The plants of this whole region are notably free from scale attack, with the single exception of the holly, which is usually considerably infested with wax scale, *Ceroplastes* sp.

Later I made a trip into the interior of China from Shanghai by houseboat, examining orchards and house plantings en route, but without finding a trace of the San Jose scale anywhere, nor any other scale insect, except in one or two instances. The greedy scale (*Aspidiotus cydoniæ?*) was found once on a few twigs only, and an occasional very slight infestation, represented by a few specimens only, of the *Diaspis pentagona*, all bearing out the idea that the climate of this region is not suitable to the ready multiplication of scale insects.

Below Shanghai one gets into a subtropical climate, and the orange, pomelo, and mandarin take the place of deciduous fruits. My entomological explorations were continued very briefly at Hong Kong, in south China, where in the markets I found the haw apple and crab apple from north China, and with considerable thoroughness in the British Straits settlements about Singapore and in Java, and later in Ceylon and the various points touched en route home. The San Jose scale story, however, ends with Shanghai.

The question immediately suggests itself, why was not Japan early infested with this insect from her near neighbor, China? This would be expected as the natural and early result of the contiguity of the two countries. The explanation is forthcoming when the history of the political relationship of these two countries is investigated. China and Japan have been sworn enemies and jealous rivals in all past time, and commercial and friendly intercourse between the two countries has been practically wanting. Japan, it is true, has taken her alphabet and much of her learning and civilization from China, and 600 years after Christ her Buddhist religion also, which now divides honors with the native shinto religion of the country. All this has come to Japan, not from China direct but through Korea. Japan conquered Korea very early in the present era, 200 A. D., in the reign of the famous Empress Jingo, and has ever since claimed and exercised a greater or less sovereignty over this country. Reference to the map of Asia indicates furthermore that Japan is not directly opposed to China, but to Korea and what is now Russian territory and Manchuria, and if she obtained any deciduous fruits from the continent, they came from Korea and not China. The orange and subtropical fruits were brought from the south, and in modern times whatever trade has been with China through the agency of the Portuguese and Dutch has been with the southern ports, where the San Jose scale does not exist.

Practically the only relations which China has had with Japan anterior to the opening of the latter country to the commerce of the world was the sending early in this era of certain embassies demanding tribute from Japan. The reply to these embassies was to send back the heads of the ambassadors. Following this, two efforts were made during the reign of Kublei Kahn to conquer Japan. In both instances the enormous fleets of the great Mongolian conqueror were utterly destroyed by a hurricane, and every Mongolian or Chinaman that succeeded in escaping the waves and getting ashore was promptly decapitated by the waiting Japanese. The Japanese made no attempt to conquer China until their notably successful war of 1895.

It will be seen, therefore, that there has been very little chance of commercial intercourse between these two countries, and this explanation seems to be the chief one in accounting for the failure of an insect common in the region north of Pekin to reach Japan. Furthermore, it may be said that the commercial intercourse which has sprung up so actively in later years with Japan has been, so far as fruits and trees are concerned, solely with the region from Shanghai southward, and the introduction of fruits and the like has not been from China to Japan but the other way, and it is quite possible that the San Jose scale which I found at Shanghai was imported from Japan on stock sent over to the local Chinese nurserymen.

As a matter of interest it may be here noted that the native home of the San Jose scale in China is a fairly well shut-off region, and this accounts probably for the failure of this insect to become a world pest ages ago. The district in question is the hill region leading up to the mountains and Great Wall and comprises the northern and northwestern frontier of China proper. Beyond the Great Wall on the north and west lies Mongolia, consisting chiefly of the vast desert of Gobi; to the northeast and separating the region from Manchuria and Korea is the little Gobi Desert; to the south and east lie the great alluvial plain, the product of centuries of mud carried down by the Yellow River—a region where cereals only are grown.

These are all effective barriers, and especially so when considered in connection with the political conditions of the past. The alluvial plain on the southeast is not now and seems never to have been devoted in the least to fruit, and farther south the climate becomes unfavorable, as already noted.

We have, therefore, as the original home of this insect a naturally shut-off area from which it could not easily escape under the conditions prevailing up to our own times.

The means by which the San Jose scale came from China to America is a matter of interest and offers room for conjecture. The San Jose scale apparently reached California on trees imported by the late James Lick. It was known that this gentleman was a great lover and energetic importer of trees from foreign countries, and my own belief is that he imported from China, possibly through this same Dr. Nevius or some other, the flowering Chinese peach, and brought with it the San Jose scale to his premises. At any rate, I believe that this insect, which should now be known as the *Chinese scale*, came to this country on some ornamental stock from North China.

PRELIMINARY REPORT ON THE IMPORTATION AND PRESENT STATUS OF THE ASIATIC LADYBIRD.

(*Chilocorus similis.*)

By C. L. Marlatt, *Washington, D. C.*

In this place a brief account only will be given of the importation of this ladybird and of the present outlook of the experiment. A detailed account of this insect, giving full life-history studies and other points of interest, will be published elsewhere. It has already been indicated in the foregoing account of the search for the San Jose scale in China and Japan that this ladybird was everywhere present in both of these countries, feeding on the San Jose scale and *Diaspis pentagona*. The latter scale insect, as was pointed out, is common to all eastern Asia, including Japan, and the East Indies, and undoubtedly, from its wide distribution and local occurrence in most out-of-the-way districts, is a native of this region and has been spread about in times so remotely past as to be beyond determination. It is probably a tropical species which has worked northward until practically the whole region as far as Pekin, in China, and the north island of Japan has been covered. Whether the ladybird, *Chilocorus similis*, was in ancient times the natural enemy of the Diaspis can not be determined, although the more wide occurrence of the Diaspis might lead to this idea. This ladybird, however, like other members of its genus, is a general feeder, and will attack other scale insects, even the young of the unarmored scale insects as well as the Diaspine scales. Wherever it was found with the San Jose scale, however, it was very evident that it fed on this scale insect with perhaps even greater readiness than it did on the Diaspis, and in our experimental breeding cages in Washington it has bred faster and done better on the San Jose scale than on the Diaspis.

After finding this ladybird so generally present with the San Jose scale, and apparently so efficient in keeping the latter within reasonable limits, the desirability of introducing it into America was very evident. While in Japan I was unable to determine whether Mr. Albert Koebele, in any of his numerous importations, had sent this ladybird into California, but it seemed more than probable that he had done so, and I wrote to Mr. Koebele, at Honolulu, H. I., and some months later after I had made my shipments I received information from him that he had sent a lot of material to Mr. Alexander Craw, and that the latter had carried it through the winter successfully, but further than that he knew nothing of it. It is possible that the material introduced by Mr. Koebele has established itself in California. Since my return from the Orient, and within a few days, I have learned from Prof. J. B. Smith that he also had had some specimens of this insect sent to him from Japan by one of his Japanese correspondents. These were liberated at once in the fall in an infested apple orchard in New Jersey and nothing has been seen of the insects since, Professor Smith believing that they perished. Judging from the small percentage of survivors of those which I imported, I think it very likely that Professor Smith's specimens all died during the winter.

As a preliminary experiment to determine the possibility of shipping them across the ocean I collected, about the middle of August, a lot of the beetles in North Japan on trees infested with San Jose scale and carried them about with me in my travels for over two weeks in a tight wooden box with some infested twigs as food. These beetles, kept under conditions which certainly were not very favorable, being among other goods in my baggage, and subject to much shaking, came through the ordeal in perfect condition, and I shipped them to Washington with a lot of others collected, with the assistance of Mr. Hori, about Tokyo.

Three packages were sent about the middle of September, and of this first sending some twenty odd specimens reached Washington in fairly good condition, active, and apparently uninjured, and Mr. Kotinsky, who was given the beetles in charge, from his records is able to say definitely that it was individuals from this first sending that successfully overwintered. A sending two weeks later was made from specimens collected about Yokohama and Tokyo, together with a few taken in the interior hill region. A third sending was made from material collected about Tientsin and later at Shanghai, the specimens at Shanghai being found feeding on the young of a wax scale on holly, the beetles occurring there in considerable numbers. The distance from Shanghai to America by boat is a week or ten days longer than from Japan, and six or seven weeks are required for their arrival at their destination in Washington. The sendings from China were received in rather poor condition, and Mr. Kotinsky assures me that all of the specimens of this lot which were alive when received died during the winter.

On leaving Japan I had made arrangements with the entomological authorities of the Central Experiment Station at Nishigahara, near Tokyo, to make additional sendings, and a little package was received early in the spring of 1902 from the chief entomologist of the station, Mr. Onuki. This material, however, came in a very bad condition, and the few surviving beetles soon perished.

The material shipped in the first instance by me was in three wooden boxes, two sent through the mails and one personally carried across the Pacific by Miss Laura Bell, whom I had met in Japan, and who kindly promised to mail it to Washington as soon as she landed in Vancouver. All of this material and the subsequent sendings also, so far as I could control them, were mailed to take the Canadian Pacific steamers to get the advantage of the northern and much cooler as well as shorter passage. I am unable to determine, the record having been lost, whether the specimens which overwintered were those personally carried by Miss Bell or those sent through the mail. At any rate, but two individuals survived. It is possible that with proper precautions a much larger number could have been successfully hibernated, but they were kept indoors, and for part of the time in heated rooms, and the survival of two was, under the circumstances, a rather fortunate outcome. Furthermore, many of the beetles were possibly spent ones when collected.

In April, after the eggs were recognized, the beetles and eggs were transferred to and kept in a jar in the greenhouse on fresh scale-infested twigs until larvæ were produced in considerable numbers. Undoubtedly a good many of the eggs first laid were overlooked because of the peculiar habits of oviposition of the beetle, which seem not to have been previously noted. Later on the eggs were discovered and some 50 larvæ were reared in this manner indoors. Afterwards the beetles and the larvæ were from time to time transferred to a big out-of-door cage, 6 feet square and 9 feet high, inclosing a plum tree thickly infested with *Diaspis pentagona*. Ultimately all of the indoor-bred larvæ were transferred to this tree, about 100 altogether, and, judging from the rate of oviposition, at least 100 additional eggs were deposited on the tree by the parent beetle before the latter perished. So far as we could determine, but one of the two surviving beetles was a female, and 200 eggs or more were obtained from her after a good many had been lost or thrown out with the wood on which she had been feeding before the eggs were recognized.

The life period of these beetles is evidently considerable. The two imported ones which survived the winter were active and vigorous until about the end of May, when they perished, the supposed male preceding the female by about a week or ten days. They, in other words, had been kept in captivity for nearly a year, having been collected early in September. This would indicate a life period of at least twelve months, because they were necessarily more than a month old from the egg when captured, and their lives were probably shortened by the unusual conditions and experiences to which they were subjected. This long life is of very considerable importance in considering the value of these insects as exterminators of the San Jose scale. Their fecundity is also considerable, as indicated by the actual securing of some 200 eggs from an imported specimen and under unfavorable conditions, not counting the loss of a good many eggs. It is not improbable, therefore, that a single female may be the parent of at least 500 young, and the period of usefulness of an individual may extend over twelve months.

The egg is normally concealed under an adult female scale. In other words, the beetle selects a suitable scale, drags out the female scale insect, and either eats it while ovipositing or drops it, turns about and thrusts the ovipositor under the slightly lifted edge of the scale, and in two or more minutes deposits a single egg. This habit of oviposition seems to be peculiar to this species. It was found later on, when the beetles became more numerous, and especially during the period when the old female San Jose scales were not so abundant, and the trees were covered with young scale insects, that other locations would be chosen by the beetle for oviposition, namely, under the loose edge of bark or like situation, or more rarely eggs would be deposited exposed on the bark.

Later in the summer other large cages were built over some pear trees infested with San Jose scale. In all five such cages were built, each of the four later ones including two pear trees about ten years of age but cut back to small size. In these cages the beetles throve wonderfully well. One cage in which two individuals, a male and a female, were placed in May, was swarming with beetles by the middle of July, and more than 100 beetles were taken from it for distribution elsewhere without greatly lessening the stock.

The multiplication of the beetles at this stage was fairly satisfactory, not so much so, however, as it should have been if the experiment had not been interfered with by the presence of certain predaceous insects to be considered later, notably the wheel bug, two species of praying Mantis, lace-winged fly larva, and the larva of *Adalia bipunctata*, it being almost impossible to free these rather large cages from all of these insects. In spite of all the drawbacks, however, the beetles have multiplied to exceed 500 specimens, perhaps 1,000, by the 1st of July from the single overwintered pair, but one of which was presumably a female.

We are making arrangements to ship these beetles to the entomologists and State experiment stations this summer and fall, and we hope to establish this ladybird in the eastern United States. It feeds voraciously on the San Jose scale and on the Diaspis. The larvæ are eating all the time, and the rate of multiplication is such that five annual broods may be counted on, the third brood in our own breeding cages being under way in the latter part of June. Whether this ladybird enemy of the San Jose scale will really amount to anything as an efficient means of controlling this pest remains to be demonstrated. The San Jose scale is its normal and natural food. It multiplies rapidly, and a larval Chilocorus destroys an enormous number of young scale larvæ in a day, by actual count 1,500 per day or about one a minute, but while actively feeding at the rate of 5 or 6 a minute. The main question to be decided is whether this insect can be successfully established in this country, and if so, whether our native predaceous insects will allow it to yield the full benefit which it should give in keeping down the San Jose scale. We make no extravagant claims, but believe that the experiment is well worth trying, whatever may be the outcome.[a]

It has been suggested that this ladybird is the same as our native species, *Chilocorus bivulnerus*, and, in fact, the superficial resemblance of the adults of the two species is so close that the greatest difficulty will be found in distinguishing them. The larvæ of the two species, however, are distinctly different in general appearance. The Asiatic has the skin of a reddish or flesh tint, the spines being black but less prominent than in our native species. The skin of our native species is a dull gray, and the general appearance of the larva, therefore, is decidedly black or dark, whereas the imported species, when full fed, is reddish. Furthermore, there are structural differences in the spines and hairs which will enable one readily to separate them irrespective of the difference in appearance, which is very striking. The beetles also can be separated, as I am assured by Mr. E. A. Schwarz, although careful anatomical and structural studies have not been made at this writing. The imported species is notably smaller on the average than our native species, and rather more brilliantly colored, and differs a little perhaps in the general shape or convexity of the wings and thorax. Furthermore, it feeds on the San José scale and the Diaspis naturally and normally. Our species, while it is often found in scale-infested orchards in the East, has never done very much good in the orchards, and does not feed and multiply on the scale in the way that it ought. For example, in the grounds of the Department of Agriculture this year we have a little orchard of pear trees thickly infested with the San José scale—the orchard in which we are establishing this foreign ladybird—and yet in all the time during the spring and early summer of this year that this orchard has been under constant and careful observation but one or two beetles of our native species have appeared, and but two of its larvæ have been seen on the trees. Yet within a stone's throw of this orchard is a tree on the grounds of the Department infested with *A. ancylus*, and on this tree, infested with a native scale insect, the *Chilocorus bivulnerus* has established itself in considerable numbers, probably several hundred larvæ being present on the tree. The history of this ladybird in the East, and as further illustrated by the instance just mentioned, seems to indicate that it prefers our native scale insects and has not yet fully accustomed itself to the San José scale nor to the recently introduced *Diaspis pentagona.* It may take hold of these new scale insects in the course of years, but it certainly does not do so at present in a manner to be of any great assistance in keeping them in check.[a] In Florida and California especially on Citrus trees it is very abundant, as a rule, and an efficient enemy of scale insects. The imported species feeds normally and voraciously on the San José scale and Diaspis, and, if it survives our climate and can be established, we may hope that it will accomplish for us some, at least, of the good results which it was seen to achieve generally for China and Japan.

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[a] It may be added to the above that during the balance of the summer this beetle did very well in the little Department grove. About a thousand beetles were distributed to various entomologists, from some of whom reports of considerable success have already been received. In Washington breeding seemed to stop toward the end of September, but we now have more than 2,000 beetles which will be overwintered Next year we should have them in quantities for general distribution.

In the matter of climate, it may be said that the region in which it occured in China and Japan will duplicate nearly enough the eastern United States or California. We have about the same summer and winter temperature and similar general conditions of rainfall and other climatic features, so that from this point of view there seems to be no reason why the imported ladybird should not do well.

That this ladybird or any other parasitic or predaceous insect will ever completely subdue the San José scale in the United States is very problematical, and there is very little doubt but that in future, as in the past, to free an orchard from this scale pest it will be necessary to take the direct and active means now being employed, such as the use of oil, or the lime, sulphur, and salt wash, or other remedies which experience shall demonstrate to be effective. What parasites or predaceous enemies may do is to keep this scale in check so that it will not be so generally abundant and destructive, and especially to keep it down in the thousands of small orchards and gardens where direct spraying operations would not often be undertaken by the owners.

In particular districts it may even put a complete check on the San Jose scale for one or several years. That this is possible is indicated by present conditions in portions of California. Mr. Craw reports in a recent letter that the San Jose scale is now exterminated in Santa Clara County, Cal., where it first appeared in this country.

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[a] Toward the end of July some 26 specimens of the native *Chilocorus bivulnerus* were caged over a San Jose scale-infested pear tree to make comparative studies of the life history and habits of the species. Unfortunately, however, all of these beetles perished, without our securing either eggs or larvæ. This rather astonishing and unexpected outcome seemed to be due to a distinct disinclination on the part of these beetles to eat the San Jose scale except in the most sparing manner.

PREDATORY INSECTS WHICH AFFECT THE USEFULNESS OF SCALE-FEEDING COCCINELLIDÆ.

By C. L. Marlatt, *Washington, D. C.*

When the breeding experiments out of doors were commenced with the imported Asiatic ladybird (*Chilocorus similis*), fears were early aroused for the success of the experiment on account of the abundance of predaceous insects[a] in the small grove of pear, plum, and peach trees attached to the insectary of the Department, which it was proposed to use as a breeding ground, inasmuch as it was thickly stocked with San Jose scale.

A great many egg clusters of the wheel bug (*Prionidus cristatus*) and egg masses of our native praying mantis (*Mantis carolina*) were found attached to the trunks and limbs of these trees. Furthermore, a large lot of the egg masses of the European praying mantis (*Mantis religiosa*) had been shipped to us by Mr. Slingerland of Cornell, and these had been placed in an open cage in the midst of this grove, so that the young could escape. The hatching of these egg masses had already begun. Later developments established the fact that both the wheel bug and these two species of praying mantis would feed on the larvæ of Chilocorus and other ladybirds. In addition to this, as the season advanced, the larvæ of the plant-lice-feeding ladybird, *Adalia bipunctata*, were also found to eat the larvæ of Chilocorus when their normal food was not readily available.

The larvæ of the lace-winged fly (*Chrysopa* sp.) preyed more or less upon the Chilocorus larvæ in the breeding cages, eggs of the former insect being deposited on the outside of the wires in bunches in several instances, and the larvæ entering in some numbers. Perhaps some of the parent insects also hatched directly in the cage. A very careful search of the cage had to be made for these Chrysopa larvæ, and a great many of them were destroyed. Comparatively few were found in the grove, and at least they were not numerous enough to occasion any serious alarm.

The chief difficulty in the cage, however, arose from the presence of the *Adalia bipunctata*. This ladybird multiplies with astonishing rapidity, its eggs being laid in masses, and day after day 50 or 100 of its larvæ and pupæ were destroyed in this cage, and it was two or three weeks before a final clearance was effected. The cage tree was a fairly good-sized plum tree, and it seemed almost impossible to discover and destroy all of the newly hatched and not very conspicuous Adalia larvæ on the leaves and twigs. The tree was badly infested with plant lice, and these furnished so much food for the Adalia larvæ that very little damage was done to the Chilocorus; but that the former would eat the latter was proved by observation in a few instances, and by inclosing them together in a jar; the smaller larvæ of Chilocorus, our native species, *bivulnerus*, being used for the experiment, were eaten, but nearly grown larvæ—big spiny fellows—were let alone.

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[a] Relating to bird enemies of Chilocorus, I am assured by Messrs. Beal and Judd, experts on the food of birds, that Coccinellids are rarely found in bird stomachs, even in California, where such insects are very abundant.

The greatest menace to the safety of the Chilocorus larvæ is the wheel bug. It was comparatively easy to keep the outdoor cages free from this predaceous bug, but had no steps been taken to destroy the wheel bugs in the grove the success of the introduction of the Chilocorus would have been very much jeopardized when the time came for their general liberation. These wheel bugs were observed feeding on the larvæ of Adalia and on the larvæ of Chilocorus. They did not feed on the scale insects, the latter being much too small for their notice, and it may be that the almost complete absence of our native Chilocorus in this grove is due to the very great abundance of the wheel bug. When our fears relative to the wheel bug were fully aroused, Mr. Kotinsky, of the Entomological Office, spent a day going through this little grove, destroying egg masses and killing the wheel bugs that had already hatched. He estimated that he killed 9,000 wheel bugs in this grove of not less than one-eighth of an acre, and subsequent results indicated that even with that number destroyed a good many had escaped, and several later inspections had to be made to fairly free the trees. This wheel bug has become extraordinarily abundant in the vicinity of Washington in the last few years, and has been increasing in numbers very considerably in its northern range, which has already been pushed as far as New York and New England.

All the egg masses of our native Mantis that could be found were collected and destroyed. Hatching, however, had already begun. The egg masses of the European Mantis were taken indoors and kept inclosed, and those that had not already hatched were allowed to come out and devour each other until the final extermination was effected by this natural means. The hatched and escaped mantides are with difficulty detected; they are of a dull grayish color, harmonizing with the bark and leaves, and their quick movements and their habit of keeping out of sight under leaves or running around to the other side of twigs when approached render their discovery difficult. All that were found in the grove, however, were destroyed.

Of the five insects mentioned above, four are dangerous enemies of the larvæ of the scale-feeding ladybirds; and, in proportion to their numbers, the benefits from such ladybirds will be decreased.[a]

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[a] A single instance was noted by Mr. Kotinsky, in late July, of the feeding of a larva of a Telephorus on a Chilocorus larva.

The observations and experience of this spring have brought into question the real value, as aids to the fruit grower, of the four predaceous insects mentioned and others of the same class which have general feeding habits. The evidence points very strongly to the conclusion that such insects do more harm by destroying beneficial species like the ladybirds feeding on scale and plant-lice than they will ever do good by eating larvæ or other soft-bodied plant-feeding insects. In other words, the injurious insects which they may feed upon to a greater or less extent are almost without exception species which are very easily controlled by other means, viz, by insecticides or methods of cropping. On the other hand, the beneficial insects which they destroy, as notably the larvæ of ladybirds, which feed on plant-lice and scale insects, include a group of insects of special importance and value to the horticulturist, for the reason that they feed on insects which are not easily controlled by other means, and which, if kept in control by natural enemies, may never require the expensive and, to the plants, dangerous treatment necessary to effect their artificial destruction. As a general proposition, therefore, I am inclined to rank all general-feeding predaceous insects as injurious and distinctly prejudicial to the interests of the horticulturist and farmer. The introduction, therefore, of any such insect, as, for example, the European *Mantis religiosa*, or efforts at their wider dissemination, are mistakes, which, in my opinion, will come to be regretted very keenly in the future. Instead of protecting these insects, I believe it will be much more to the general advantage to destroy all egg masses of mantids and the wheel bug; and to view the lace-winged flies with suspicion, if not to class them as absolute foes.

ADDENDUM.

A very important hymenopterous parasite must be added to the list of natural enemies of the Asiatic ladybird. To our very great disappointment and astonishment, early in September it was found that the pupæ of the last brood were much parasitized, causing a loss of more than 10 per cent of this brood. As many as could be of these parasitized pupæ have been collected, and from them has been reared a little Chalcidid fly, *Syntomosphyrum esurus* Riley, from five to seven parasites coming from each pupa. This insect belongs with a group of secondary parasites, but no trace of the primary parasite could be found in any of the pupæ examined, although later breeding may develop the primary parasite during the winter or next spring. The larvæ were found free in the abdominal cavity of the Chilocorus pupa, and ultimately all of the substance of the pupa disappears. In one or two cases where parasitism had only just begun to make itself evident, half-grown larvæ were found. These were filled with the yellow fluid contents of the Chrysomelid, and were orange yellow in color. The older larvæ in the nearly empty shells of the pupæ were whitish in color. That all of these larvæ are of the parasite mentioned above can not be definitely said. Dr. Howard, who examined the material with the writer, is of the belief that the primary parasite will prove to be *Homalotylus obscurus* How., the common coccinellid parasite of this country. If the parasite bred proves to be a true secondary parasite, as believed, its presence in such numbers in the pupæ of Chilocorus is a matter for gratification. If, on the contrary, it be a primary parasite, it seriously threatens the success of the imported Chilocorus and all allied ladybirds. The status of this parasite is given in the appended note by Dr. Howard:

All of the Tetrastichinæ known and whose exact host relations have been determined are hyperparasites. *Syntomosphyrum esurus* Riley has never been proved to be either secondary or primary. It is or was a common parasite of *Aletia argillacea* in the cotton fields of the South late in the summer. It issued frequently and in great numbers from old chrysalids left hanging bare upon the cotton stalks. The chrysalids on being opened were found full of this parasite, and no trace of a primary parasite was ever found. Hence this insect was considered in Bulletin 3 of the United States Entomological Commission, and in the Report on Cotton Insects, by J. H. Comstock, published by the Department of Agriculture in 1879, to be a primary parasite. The question as to whether it might not be a secondary parasite was raised by me in the Fourth Report of the United States Entomological Commission. It was reared, as recorded in Bulletin 5 (Technical Series), of this Division, by Dr. A. D. Hopkins, at Morgantown, W. Va., from *Orgyia leucostigma*. It was reared abundantly in 1896, in the late winter and early spring, at Washington, D. C., from the chrysalids of *Hyphantria cunea*. Moreover, it was reared by F. M. Webster, in 1889, on May 3, according to the notes of the Division, from the galls of *Trypeta gibba* Loew on *Ambrosia artemisiæfolia*. But these Trypeta galls, especially late in the season, are apt to contain several different kinds of insects, not only primary parasites, but frequently lepidopterous, coleopterous, and dipterous larvæ, so that the rearing from the gall means nothing at all; the presumption, however, being that the insect came from the Trypeta either as a primary or a secondary parasite.

Summing this evidence all up, we have the insect reared undoubtedly from lepidopterous chrysalids and from coleopterous chrysalids—that is to say, the Coccinellids under consideration—and also possibly from dipterous insects. Unity of habit—that is to say, unity of host relation—is so marked among the Chalcididæ that wherever such a diversity in the apparent hosts occurs it has become my rule to place such parasites as undoubtedly secondary or tertiary parasites. The primary parasites of a given group of insects belong to certain definite groups. Examples are so numerous that they need not be mentioned. In no case in the whole family, to my knowledge, are the parasites of a single genus parasitic upon more than one order of hosts, and in some instances they are confined even to individual families of hosts, and the assumption that a single species of Chalcidid may be reared from Coleoptera, from Lepidoptera, as well as possibly from Diptera, is almost an absurdity. These are the principal reasons upon which I base my belief that *Syntomosphyrum esurus* is a hyperparasite.

After the reading of these papers they were opened for discussion.

Mr. Webster commented on the value of what Mr. Marlatt had accomplished, and felt that the least the Association could do was to extend to him a vote of thanks. He then made a motion to that effect. Mr. Webster, continuing, stated that it would have been exceedingly interesting if Mr. Marlatt could have gone to Korea, but doubtless this was not possible. The main object, however, was accomplished. He wondered if Mr. Marlatt would not have had as good success with material gathered from Europe instead of Japan and China. He did not consider that there was quite so much danger from our native predaceous insects as Mr. Marlatt had suggested, and called attention to the value of the twice-stabbed ladybird in clearing maple trees badly infested with the common maple Pulvinaria. The occurrence of *Chilocorus similis* in Europe would indicate that it had a variety of host insects, and that it would feed on almost any species of scale. The insect, however, seemed to have acquired a greater taste for the San Jose scale than any other of the scale insects, and he thought that it would gain about the same status of importance and abundance as other native species, but that it would probably be a little more fond of Aspidiotus and Diaspis species than is *C. bivulnerus.* Mr. Webster was very glad that the studies in Japan and China had been made, and thought American entomologists had a great deal to thank Mr. Marlatt for.

Mr. Scott rose to second the motion made by Mr. Webster. He considered this one of the most important attempts in experimental entomology, and thought Mr. Marlatt was to be congratulated as contributing such valuable work along this line.

The president then put the motion, and it was heartily carried.

Mr. Smith stated that Mr. Marlatt's paper had interested him greatly, and he considered that the most important feature of the work was that Mr. Marlatt had shown that China was the native home of the San Jose scale, and that it was there kept in check by native insects. The question had always been, however, whether the enemy which kept it in check in its home would do the same in the eastern United States. He felt satisfied from investigation in California that our native species was there one of the most active enemies of the San Jose scale. He had found there, quite early in the season, that not only had there been a brood of the ladybird larvæ before the scale began to breed, but that eggs were already scattered over the trees for a second brood. He had seen larvæ as well as adults feeding on the dormant scale. He felt quite certain that this was the insect doing most good in keeping the scale in check in that State. Just why the beetle would not breed with us in the East as continuously he was at a loss to explain. He had watched it for several years, and was convinced that it did not have more than two broods a year in New Jersey. He stated that the beetles were eating on his trees at present, but not at the same rate as in California. He had found them on trees that had never been treated as well as on those which had been treated.

He had in his experiment orchard a number of trees that had never been treated, which showed resisting qualities and did well. The scale never increased beyond a certain point, and then practically died off. He had never found any wheel bugs in this orchard, so that these could not be considered in accounting for the disappearance of the ladybirds. They should hardly rank as enemies, but might form an important factor in the destruction of the larvæ of this ladybird beetle if it really appeared in considerable numbers. He knew that many of our predaceous insects eat a great variety of food. The wheel bug will eat a webworm, the larvæ of the elm-leaf beetle, or anything else in its way with equal pleasure.

Mr. Smith had been able to determine positively that the larva of the two-spotted ladybird eats the young crawling scale larvæ. He thought, as a result of his observations in California, that there was a possibility that the California species of Chilocorus was different from our Eastern form, though they were quite similar in appearance. He had had a number in the early stages and could not make out any difference between them. One year 200 California specimens had been sent to him, and in comparison with the Japanese specimens and those from the eastern United States he was not able to tell which came from one place and which came from the other. To secure the lot that had been imported from Japan, he wrote to every entomologist in that country whose address could be secured. Individual letters were sent, with offers to pay all expenses, and in this way a considerable number of two species were secured, one a large form, the name of which was not remembered at that moment, and the other a smaller species, *Chilocorus similis*. These beetles were taken to a very scaly orchard and liberated on the trees at a season of the year when all stages of the scale were present, and when there was an abundance of time for the beetles to deposit eggs. So far as he knew there had been no survivors. He had not been able to find any larvæ and had not recognized the difference between those of the twice-stabbed ladybird and those of the *Chilocorus similis* until Mr. Marlatt had pointed it out in his paper. He considered that Mr. Marlatt was very conservative in his claims in regard to the imported beetles and thought his suggestions well worth the trial. He was in doubt as to the importance of the injury resulting from the wheel bug, but stated that this species did considerable good in controlling the fall webworm. In response to a query, Mr. Smith stated that the *Chilocorus similis* had been placed in the orchards referred to three or four years ago. He further stated that the orchard had been pretty well cleaned of scales by other means, but that he had never seen any descendants of the imported insects.

Mr. Sanderson observed that *C. bivulnerus* was very common in Delaware and that he knew of several orchards where it kept the

Forbes scale in check. The Forbes scale would sometimes become quite injurious and peach trees would often be killed. It was his observation that the *C. bivulnerus* was largely instrumental in controlling this species, and while he had observed the wheel bug to be very common, yet he had never noticed that it fed on the larva of this beetle.

Mr. Felt stated that he desired to congratulate Mr. Marlatt on his efforts in searching for the native home of the San Jose scale and procuring its natural enemies. He stated that there were no wheel bugs in New York State, so that this insect could not have a hand in destroying parasites. He stated that there were very few of the *C. bivulnerus.* So far as his observations went, he considered the ladybirds most valuable as enemies of plant-lice. Plant-lice were very abundant in Albany in 1897, and ladybird larvæ were so very numerous as to attract considerable attention.

Mr. Hopkins remarked that there was great difficulty in determining the different species of closely related scolytid beetles, and suggested the importance of a close study of closely related species in all stages to definitely determine their distinctness. As an example, two scolytids had been described from Germany as different species, but were afterwards considered the same. After a close study, however, he had found that the two European species belonged to two quite distinct genera. On close study he had found striking differences, not only in habits, but in structure.

The next paper was presented by Mr. Quaintance.

ON THE FEEDING HABITS OF ADULTS OF THE PERIODICAL CICADA.

(*Cicada septendecim* L.).

By A. L. QUAINTANCE, *College Park, Md.*

But little accurate observation seems to have been made on the feeding habits of the adults of the periodical cicada, or so-called seventeen-year locusts. A review of the rather scant literature on the subject indicates also that considerable diversity of opinion prevails among entomologists and others as to the extent to which they feed, and, on the whole, the opinion probably prevails at the present time that the adults, particularly the males, feed but little, if at all, during their brief aerial life of about thirty days. The first note in reference to this point which I have seen is by Messrs. Walsh and Riley, in the American Entomologist, Vol. I, p. 67 (1868). It is here stated, under a general discussion relative to the sting of the periodical cicada, that "the beak is an organ which both sexes of the cicada possess, and by which they take their nourishment. We have ourselves seen them insert it into and extract it from the branches of different trees, and know that the operation is quite rapid and that the instrument is quite sharp and strong." The same statement was repeated by Professor Riley seventeen years later.[a] Professor Riley also adds a note in reference to an experience of Mr. Gustavus Pauls, in which an apricot tree was so severely injured by the puncture of their beaks in the course of feeding that he took from the tree a gallon of coagulated sap; and he attributes the death of some of his trees to this cause. In the course of his observations on the seventeen-year locusts on Staten Island in 1894,[b] Mr. W. T. Davis says: "The black birch and sweet gum were also great favorites, both as depositories for the eggs and also from which to draw sustenance. It was no uncommon matter to see rows of cicadas along the branches of the sweet gum, each insect with its proboscis stuck into the bark." He also adds, speaking of sumach (*Rhus glabra*): "Though the cicadas were fond of sucking the sap of this bush, yet they rarely tried laying eggs in its tissues."

According to Dr. J. B. Smith,[c] "very little injury is done in feeding, the food consisting of sap of trees of many kinds." Dr. A. D. Hopkins[d] states that the adult cicadas feed but little, if at all.

In our latest and most authoritative report on this interesting species, Bulletin No. 14, new series, Division of Entomology, United States Department of Agriculture, by Mr. C. L. Marlatt, it is stated, doubtless after due consideration of all the evidence bearing on the subject, under the caption "Food habits of the adult insects," p. 72, that "the taking of food in the adult stage seems to be of rare occurrence, and has been observed and commented on by a few of the entomologists who have studied the species. That the periodical cicada feeds at all has even been questioned, and it is quite possible that in some of the cases where it was supposed to have been feeding, the action of the insect was misinterpreted. Such feeding is limited, at any rate, to the female, as in this sex only do we find a perfect digestive apparatus, that of the male being rudimentary."

My attention was called to this question during the height of the abundance of the present brood by the receipt of a letter from a correspondent to the effect that the cicadas were feeding on his orchard trees, and desiring a remedy. After writing him to the effect that he was doubtless mistaken in his observations, as the cicadas fed but little, if at all, in the adult stage, a visit the following day to a near by orchard of three or four-year-old apple and pear trees showed that the insects were there in great numbers and were feeding quite generally. On practically every tree both sexes were to be observed, ranging in numbers from 10 to 40, with their beaks stuck straight down against the bark, to all appearances feeding after the usual manner of homopterous insects. In numerous instances the insects were observed, when disturbed, extracting the thread-like setæ from the plant tissue. The insect occurred most usually, in this young pear and apple orchard, along the trunks and larger limbs, which, early in the morning and rather late in the evening, were frequently quite wet with sap which had exuded from the punctures made by the setæ of the cicadas. This exudation of sap was frequently noticed to immediately follow the withdrawal of the sucking apparatus of the insects to such an extent as to run down the trunk a distance of 4 or 5 inches, and the loss of sap in this way and that taken up by the insects would apparently be a considerable drain on the vitality of the plant.

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[a] Bulletin 8 (o. s.), Div. Ent., U. S. Dept. Agric., p. 14.

[b] Nat. Science Association of Staten Island, Vol. IV, No. 9, September, 1894, pp. 33–35.

[c] Bulletin 95, New Jersey Agricultural Experiment Station, p. 5.

[d] West Virginia Expt. Sta. Bul. 50, p. 9, and Bul. 68, p. 265.

Since the date of making the above observation at College Park on June 5, I have paid special attention to the feeding habits of the cicadas in other parts of Maryland, where my work has taken me, and without exception, in every place visited throughout the range of the insect, both sexes have been observed to be feeding in greater or less abundance. At Hancock, in Washington County, the cicadas were very numerous in a young apple orchard, from 6 to 18 being noted on the several trees closely examined. At Annapolis Junction, in an orchard of two-year-old peach trees, the insects were exceedingly abundant, both feeding and ovipositing. On one undersized tree in this orchard twenty-four cicadas were counted, each with its beak stuck straight down against the bark, and the tree was quite wet along the larger limbs and trunk by the sap exuded from the punctures made. In large oak, maple, and probably other trees, the insects feed very generally in the higher parts of the tree on the more tender branches and limbs. I have been able to establish this by numerous observations with an opera glass from the higher windows of the several college buildings, which are surrounded with large trees of doubtless the original forest growth. This habit of feeding in the higher parts of forest trees will doubtless account to some extent for the opinion that but little, if any, feeding is done, since here there would ordinarily be but little chance of observation. While no attempt was made to determine the various plants used as food, the cicada was observed feeding on the following: Apple, pear, peach, Japan plum, maples and oaks of several species, Carolina poplar, elm, hickory, and *Ilex opaca*.

To determine more definitely the extent to which the beak and setæ of the cicada were inserted into the tissues of the food plants, many beaks were snipped off, by the use of a fine pair of scissors as close to

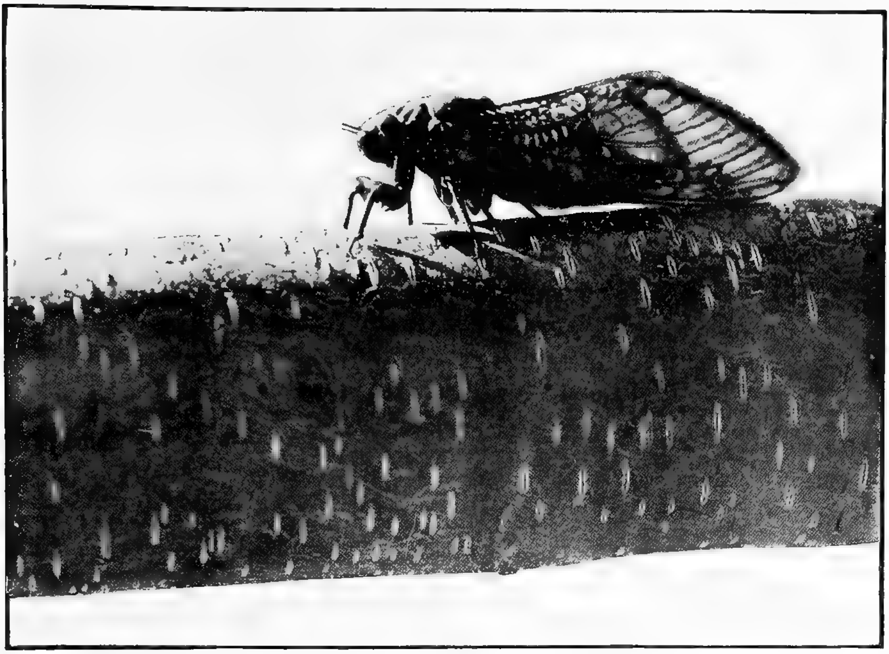

FIG. 1.—CIGADA IN THE ACT OF FEEDING.

About twice natural size.

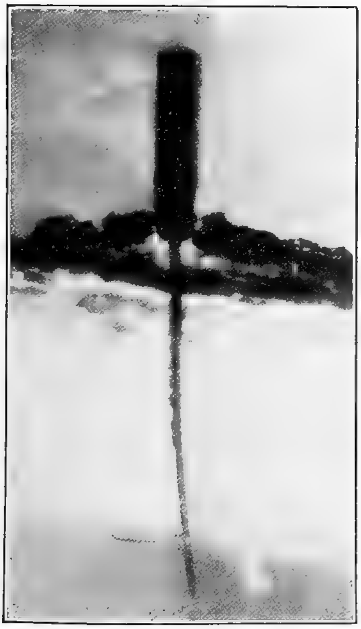

FIG. 2.—BEAK AND SETÆ OF MALE PERIODICAL CICADA IN WOOD OF CAROLINA POPLAR.

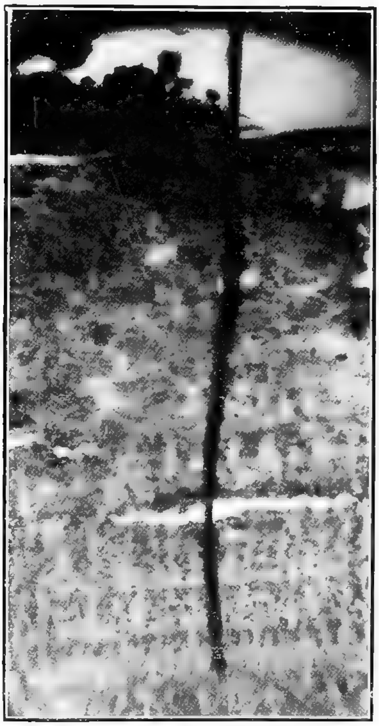

FIG. 3.—SETÆ OF FEMALE PERIODICAL CICADA IN APPLE TISSUE.

Much enlarged—original.

their origin as possible, while the insects were in the act of feeding. A block of wood containing the setæ was cut from the tree and sectioned with the microtome (Plate I). The accompanying photomicrograph illustration shows a section thus prepared with the beak and setæ inserted. The beak, in this case, was taken from a male feeding on the Carolina poplar. Many sections have been made, and show no appreciable points of difference from the one illustrated. It will be noted in the illustration that the sheath penetrated somewhat into the bark, but is not pushed into the harder wood. In all specimens examined, this seems to be true, the beak being pushed only slightly into the outer bark, while the setæ are thrust to variable depths into the cells of the plant.

Despite this evidence as to the fact that the adult cicadas feed, which in the case of almost any other insect would have been convincing, doubt has recently been expressed as to whether it could be considered true that the cicada feeds in the sense of taking nourishment. The use of the mouth parts as above illustrated was considered to be the result more of hereditary instinct than anything else, and, while it was admitted that the beak might be thrust into the tissues, this was considered to be simply a sampling or tasting of the juices of the plant on the part of the insect. At various times, but particularly rather late in the evening, both sexes of cicadas have been taken from trees in the act of feeding, and quickly opened, so as to expose the stomach, or so-called crop, and this has been found in many instances to be distended several times its usual size with the sap taken from the trees.

According to Marlatt (l. c.) the alimentary tract of the male is considered to be rudimentary, and no food is taken by this sex. As shown in the foregoing, males have been observed many times in the act of feeding, and the photograph to which attention has been called shows the setæ of a male in the tissues of the plant. Males, as well as females, have been taken in the act of feeding, and their stomachs found distended with sap. Furthermore, dissections of the alimentary tract of the male shows that it is not rudimentary, but apparently normally developed for this group of insects. The intestine, while small, is continuous to the anus, and is reasonably large for insects subsisting on liquid food. The œsophagus and salivary glands are well developed, while the stomach and crop is rather large and capable of considerable distention.

The setæ are long and tubular and much coiled with the intestine, all being more or less bound together with tracheal threads, so that dissection is rendered somewhat difficult. On the whole the alimentary canal of the male seems to be as fully developed as that of the female. It may be mentioned as a point of importance in this connection that both sexes void quantities of fluid excrement from the anus, as I have frequently observed, and which is very noticeable on the lower foliage and on the ground, under trees inhabited in some numbers by the cicadas. This discharge of fluid could not reasonably go on without the insect's taking food from time to time.

From the evidence in hand I am led to believe that both sexes of the periodical cicada normally take food in the usual sense of the word, and that in the case of young orchard trees, at least adjacent to woods, where the insects are likely to be abundant, injury may result to the plants attacked.

In discussing this paper Mr. Marlatt said that he wished to congratulate the author on having presented the first really thorough and careful observations which had ever been made on the feeding habits of the periodical cicada. Referring to the published statements in his Bulletin No. 14 on the feeding habits of these insects, he said that at the time this bulletin was written it was impossible to make field observations, and that most of the statements relating to food habits were drawn from general literature on the subject, but they included the reported observations of some of the best entomologists which this country has had, namely, Walsh, Riley, and Smith. In his own personal observations he had never noticed the cicada giving any special evidence of feeding. He was very glad that Mr. Quaintance had gone into the matter so fully, and felt convinced that it had been demonstrated that the cicada does normally and frequently, but perhaps not invariably, take liquid nourishment from trees and plants.

Mr. Smith thought that Mr. Marlatt was justified in his statements, and it was his opinion before hearing this paper that the digestive system of adults of the periodical cicada was rudimentary and not adapted to carrying off food stuffs. He had observed it feeding and had some twigs punctured for feeding purposes, but had often examined the digestive organs of both sexes and came to the conclusion that the cicada did not feed as a rule. Most of his examinations, however, had been made on specimens that had been dead for some time, and it was probable that the digestive organs had quite collapsed.

Mr. Quaintance stated that the intestine of the cicada was very small and thread like and was closely attached to the inner surface of the dorsum of the abdomen of the insect, and unless the dissections were carefully made, and under water, it would be readily overlooked.

Mr. Marlatt, in further discussion of the food of cicadas, said they fed quite industriously during the warm season of each of their seventeen years of underground life, and that it was, therefore, not unreasonable to suppose, in the absence of direct evidence to the contrary, that for the short period of their aerial life the nourishment previously gained would suffice, and hence the feeding in the adult stage might reasonably have been supposed to be a matter of chance. In his own observations he had never noticed the cicada feeding, and he thought it still open to question whether it was always necessary for the adult cicada to take food. That they did take food Mr. Quaintance had clearly shown. He doubted very much, however, whether the puncturing which they did to trees and the small amount of sap taken caused any special damage to the plant attacked. As an argument for the necessity of feeding of the periodical cicada might be mentioned the fact that when kept in confinement for a few days without food they invariably die.

Mr. Hopkins called attention in this connection to certain insects that can live a long time without food. Both the larvæ and adults of a clerid beetle, collected by him in Germany, had lived several months without food in little vials.

Mr. Quaintance queried if the feeding habits of adult cicadas might not possibly vary with different broods. He asked for information as to the relative abundance of the dwarf (*cassini*) variety.

Mr. Marlatt replied that he had had at different periods opportunity of witnessing three broods of the periodical cicada. In the first two of these he had failed to notice any of the smaller form, all of the specimens being of the normal large size. The present year fully 50 per cent of the early appearing individuals were of the small form. He had been informed also by Professor Galloway, who had made a trip through the West to St. Louis during the cicada prevalence, that the woods were filled with the deafening noise of a cicada, the song being entirely different from the ordinary one. From Professor Galloway's description the small cicada was undoubtedly the one heard, indicating its general abundance this year throughout the range of the brood.

Mr. Hopkins stated that in 1897 the small variety was very abundant in West Virginia, and that it came later than the others.

Mr. Quaintance remarked that the small form came after the large form had disappeared to a considerable extent in Washington County, Md.

The meeting then adjourned to reassemble at 2 p. m.

AFTERNOON SESSION, SATURDAY, JUNE 28, 1902.

The meeting was called to order by the president, who called for the report of the committee on membership. The committee reported as follows:

REPORT OF COMMITTEE ON MEMBERSHIP.

Your committee to consider the question of membership would report as follows:

We recommend the adoption of a by-law to the effect that it be the duty of the officers of the Association, each year previous to the annual meeting, to carefully examine the list of members and recommend to the Association the dropping of such names as have in their opinion no further place upon our roll; such recommendations to be acted upon by the Association, and a vote of two-thirds of the members present to be sufficient to drop any name.

That in the interpretation of the paragraph of the constitution regarding the election of new members it be understood that an "economic entomologist" is a person who has been trained in entomological work and whose known work or published papers show him to be capable of conducting original work in economic entomology.

That the term "practical entomologist," referring to associate members, be held to indicate persons who have done general work in entomology and who have, by published papers or otherwise, given evidence of their attainments in such work.

That associate members be listed separately in the published roll or the fact that they are associate members be indicated in the list.

Herbert Osborn, *Chairman.*
John B. Smith.
E. P. Felt.

This report was unanimously adopted; and the report of the committee on resolutions was then read and adopted, as follows:

REPORT OF COMMITTEE ON RESOLUTIONS.

Whereas, the effect upon fruit trees of oil sprays for the San Jose scale has been very diverse in different States, and a study of the chemical composition of the petroleum oils used and their physiological effect upon fruit trees seems desirable: Therefore, be it

Resolved by the Association of Economic Entomologists, That the attention of the honorable Secretary of Agriculture be called to the desirability of the Department's undertaking a joint chemical, entomological, and physiological study of the problems involved.

Resolved, That we appreciate most fully the past favors of the Department of Agriculture in publishing the proceedings of this Association, and respectfully request that the proceedings of the present meeting be published as heretofore.

Resolved, That the thanks of the Association be tendered to Dr. W. J. Holland, and to the citizens of Pittsburg, whose favors have rendered the comforts and pleasures of the members in attendance at this meeting a feature to be remembered.

Resolved, That this Association has listened with great interest to the report of Mr. C. L. Marlatt's explorations in Japan and China to study the San Jose scale and its natural enemies, undertaken largely at his own expense; that we feel that the subject of applied entomology in America has been greatly developed and advanced thereby, and that we as an Association hereby tender to Mr. Marlatt our thanks for his generous and unselfish labors.

Respectfully submitted.

F. M. Webster, *Chairman.*
Herbert Osborn.
W. E. Rumsey.

REPORT OF COMMITTEE ON NOMINATIONS.

The committee on nomination of officers for the coming year reported as follows:

Dr. E. P. Felt, Albany, N. Y., president.
Mr. Wm. H. Ashmead, Washington, D. C., first vice-president.
Prof. Lawrence Bruner, Lincoln, Nebr., second vice-president.
Prof. A. L. Quaintance, College Park, Md., secretary and treasurer.

The report of the committee was unanimously accepted, and the secretary was instructed to cast the ballot for the Association.

The secretary presented the name of Mr. E. G. Titus as a candidate for membership in the Association. This name was proposed by Mr. Webster, who explained somewhat at length the training which Mr. Titus had had, the work he had done and his eligibility to membership. After some discussion by members Mr. Titus was elected to active membership.

There being no further business before the Association, the regular program was resumed:

NOTES FROM DELAWARE.

E. Dwight Sanderson, *Newark, Del.*

At the last meeting of the entomological section of the Association of Agricultural Colleges and Experiment Stations the writer described the differences between the more common species of aphis affecting the apple and pear, and a further report concerning them will be found in the 13th report of the Delaware Agricultural Experiment Station, now in press. Our most common species, usually written *Aphis mali* Fitch, is entirely distinct from *A. mali* of Fabricius, which is a synonym of *A. pomi* De G., and the name *A. mali* must therefore be abandoned. I have consequently described Fitch's species as *Aphis fitchii* n. sp., in recognition of his very careful description of it. This name must be regarded as somewhat tentative, however, as Prof. Slingerland is of the opinion that *Aphis annuæ* Oestlund will probably prove to be the same species, in which case it would have priority, and there are certain European species which further study may show to be identical. Meantime the name *fitchii* will clearly designate the species discussed, and the confusion formerly existing will be obviated. This spring I again attempted to breed this aphid in the insectary upon wheat and various grasses, but seemed to fail entirely, none being observed to reproduce on them, either when inclosed in glass cylinders or when free. I also carefully examined a number of wheat fields and various pieces of grass at the time the aphides were migrating from the apples without finding them on the grass. Having found no aphides on the grasses in the insectary up to June 1, they were not examined again until June 25, when I found one of them well covered with an elongate yellowish-white aphis which had caused the leaves to wilt and become streaked with white. These aphides were decidedly elongate, with cornicles and cauda concolorous with body, cornicles tipped with black, antennæ and eyes black, and sometimes with a greenish and sometimes a reddish splotch at the bases of the cornicles, but usually without such marking. A few pupæ were observed but no winged females. It is possible that this may be the same species as the spring form on the apple, as it has certain "ear marks," though in general it is entirely dissimilar. Should it prove to be the same, there must be a very enormous and decidedly remarkable mortality of the winged females migrating from the apple in May, for which there seems no good reason.

Aphis pomi DeG. seems more abundant than usual this year and becoming more widely distributed. It is unquestionably one of the worst insect pests of the young apple orchard and of old trees being top-worked, and how best to combat it is somewhat of a problem. It should be noted that some varieties of apples are decidedly preferred to others by the aphides, trees of another variety next to badly infested trees often remaining unmolested. Very frequently this season I have found colonies of this species of a bright orange-yellow color instead of the typical bright green, and also intermixed with the green forms. This striking variation has not been previously observed so far as recorded, and I regret that I have been unable to ascertain whether the yellow aphides reproduce the yellow form.

Owing to the manner in which they curl the leaves, *Aphis sorbi* and *pomi* are exceedingly difficult to combat; *Aphis fitchii* rarely does sufficient damage to warrant treatment. Washes of whale-oil soap, 2 pounds to a gallon of water, and lye 6 pounds to 50 gallons have both failed to destroy the eggs. Prof. Aldrich reports having killed the eggs with 33 per cent crude petroleum with water, using a heavy western oil of .954 specific gravity. We have sprayed several young trees with pure crude petroleum ("insecticide oil"), and though there seemed to be fewer young aphides on these trees, there were enough to soon stock the tree with lice. It seemed probable that the gummy residue left upon the surface of the bark was fatal to many of the newly hatched lice, as the crude oil had undoubtedly had a beneficial effect.

Fifteen per cent kerosene mixed with either water or Bordeaux mixture has not proven very satisfactory for destroying the aphides; 20 per cent kerosene seems more effectual and fairly satisfactory; 15 or 20 per cent crude petroleum is quite effectual and does no injury to the trees. When mixed with Bordeaux mixture it tends to make the latter collect in drops, and this is therefore an undesirable combination. Kerosene mixed with Bordeaux mixture and Paris green gives as even a coat upon the foliage as without the kerosene, and would seemingly form a perfect insecticide and fungicide where it can be used to advantage.

I am inclined to the view that in many cases the kerosene sprays are not effectual owing to the improper working of the pump. Kerosene emulsion made with soap and diluted to contain 15 per cent kerosene has failed to destroy the lice. Whale-oil soap, 1 pound to 6 and 8 gallons of water was ineffectual, though 1 pound to 7 gallons was fairly satisfactory. The latter is rather too strong, however, to use on tender foliage. Rose-leaf insecticide, an extract of tobacco, one part to from 25 to 40 parts of water, is the most satisfactory spray we have used against these aphides. It is, however, most disagreeable to apply and rather too expensive for extensive use. Undoubtedly tobacco water made by boiling 1 pound of refuse tobacco in 1 gallon of water, with an equal amount of water added, will prove to be a good remedy, though we have been unable to give it a thorough trial.

The most satisfactory method of destroying these aphides on young trees is by fumigation. In 1899 we made several tests in fumigating them with hydrocyanic acid gas and found that they could be readily destroyed in ten or fifteen minutes. This spring we had a fumigator of the Geneva type constructed, covering it with strong muslin, which was thoroughly painted with thin glue, and it proved entirely satisfactory. This frame contained exactly 200 cubic feet. The aphides were entirely destroyed by burning 2 ounces of tobacco leaves and fumigating for fifteen minutes; also with one-half a roll of "aphis punk" for twenty minutes. A larger amount of the latter would probably be as effectual in a shorter time. "Aphis punk" is simply paper dipped in a tobacco extract, and is in a handy form to use, though rather expensive. Nikoteen and Nicoticide, both concentrated extracts of tobacco, were used very successfully by diluting with water and evaporating in shallow pans over an alcohol lamp furnished by the manufacturers. One and one-half cubic centimeters of Nikoteen diluted to 15 cubic centimeters with water killed the aphides in fifteen minutes, as did 4 cubic centimeters diluted to 15 cubic centimeters in eleven minutes. It requires about five minutes for the Nikoteen to evaporate. Five cubic centimeters of the Nicoticide diluted with 5 cubic centimeters water killed the aphides in ten and twelve minutes. The Nicoticide "is a very strong solution containing 40 per cent of nicotine" (quoted from a letter of manufacturers); it is a thinner and more volatile liquid than Nikoteen or Rose Leaf, evaporating over the lamp in about three minutes, and seems to be more rapid in its effect upon the aphides. We are inclined to regard this as the most satisfactory method of fighting these aphides upon young orchards. Usually but a few trees are infested here and there, and as the lice do not spread very much until the trees become overcrowded, by fumigating these few trees the injury can be almost entirely checked, as the fumigation destroys practically every aphid, whereas the best spray can not reach a very large percentage of those protected on the curled leaves.

A plain box or bell tent made of heavy, tight-woven muslin (we found a brand termed "Cast iron," in use by hot-air balloonists, very satisfactory) and painted with glue would be fully as satisfactory for use on small trees, and much cheaper. The materials for a tent should not cost over $2, and the making is a simple matter. With a dozen of these 2 or 3 men could get over a considerable number of young trees in a day.

The strawberry root-louse (*Aphis forbesi.*)—Various means of destroying the strawberry root-louse upon plants prior to setting have been thoroughly tried. Sixty thousand plants were fumigated in two lots in a nurseryman's fumigation house for thirty and forty minutes with 0.2 gram KCN per cubic foot without injury to the plants, and the lice were killed as far as observed. The plants were laid loose, one or two layers deep, on frames of wire netting. Subsequently 7,000 were fumigated in several lots in a small box containing 10 cubic feet for thirty minutes with 0.2 gram KCN per cubic foot and 0.3 gram KCN for twenty-five minutes without injury to the plants.

From 20 to 75 per cent of plants dipped in whale-oil soap, 1 pound to 6 gallons of water, were killed, as were from 50 to 75 per cent of various lots dipped in kerosene emulsion diluted 10 times. Tobacco water (1 pound of stems boiled in 1 gallon of water, used undiluted) was this year used as a dip by a number of large growers with marked success. The beds of one party who has used it for several years showed its good effect. Plants dipped in Rose Leaf insecticide, 1 part to from 20 to 40 of water, were uninjured and the lice were killed. The main difficulty in fumigating or dipping prior to setting is that growers are desirous of setting early, and as with many insects a few of the eggs do not hatch until unusually late, dipping or fumigating at the time the growers wish to plant does not destroy these. To destroy the eggs we have tried burning over the beds, as the eggs are all upon the leaves as far as observed. By covering with straw or similar material which will make a quick fire and burning over just as the plants commence to grow in the spring, the foliage can be burned off without injury to the crowns and the plants will shoot out again, giving a good foliage by the time it is desired to set them in a new bed, and producing fruit the same as if unburnt, except perhaps being a trifle later. The burning should also be of value against other strawberry insects and diseases.

The codling moth.—In experiments with remedies for the codling moth in 1901 it was found that two bands on a tree caught 15 per cent of the larvæ infesting apples upon 5 trees, the percentage varying from 8 to 25 per cent, varying almost exactly inversely to the effectiveness of the spray used. Numerous larvæ and pupæ were collected from these bands, and it was found that a very large percentage hibernated over winter, there being, therefore, but a partial second brood.

Our chemist has kindly analyzed samples of two lots of arsenite of lime and one of arsenite of soda, made according to the usual formulas, with pure arsenic and boiled by steam, and in each case they contained but three-fourths the supposed amount of arsenious acid. The arsenite of lime was used last year at a strength equivalent to 1 pound of Paris green to 215 gallons of water, with a benefit of but 20 per cent over untreated trees for the whole season. It is believed that arsenites of lime or soda should be used at the rate of 1 pound or 1½ pounds of AS_2O_3 to 160 gallons of water to be effectual, and they are being thoroughly tested at various strengths this year. Paris green, 1 pound to 160 gallons of water, and Disparene, an arsenate of lead, manufactured by Bowker Insecticide Company, 3 pounds to 150 gallons, were also tested upon 5 trees each, with 5 check trees, the dropped and picked apples being counted on all. One spraying of Disparene proved as effectual as two of Paris green. It will be noticed that the benefit derived is not so much in the smaller percentage of wormy picked fruit, though that is marked, as in the very much smaller percentage of wormy fruit dropped, the perfect fruit dropped being approximately the same for all the sprayed and unsprayed trees. With 60 per cent of the apples wormy upon the check trees, a benefit of 87 per cent for the season was secured by spraying twice with Disparene, of 60 per cent by spraying once, and of 61 per cent by spraying twice with Paris green. Of the dropped fruit, that sprayed with Disparene twice showed a benefit of 75 per cent, against 52 per cent with that sprayed with Disparene once and 54 per cent with that sprayed with Paris green twice. Likewise with the picked fruit, Disparene applied twice produced a benefit of 96 per cent, against 66 per cent when applied once and 69 per cent with Paris green applied twice.

The periodical cicada has been present the past month in northern Delaware, but so far as ascertained has not occurred in the two lower counties, and I have been unable to secure any records of its occurrence there in 1885. The pupæ first emerged in numbers on May 22, and continued except on a few cold nights until June 2, the most ascending on May 30. Several dogs and cats have been observed to relish the adult cicadas. The turrets or mounds of the pupæ were observed under pine and spruce trees on several old lawns and in a piece of pine timber burned over about the middle of May. The largest turrets were found under a small outbuilding, the floor of which was about a foot above the ground. Here the turrets completely covered the surface of the soil, reminding one of a house-top view over city chimneys, and were from 3 to 6 inches long.

The cicadas have been most abundant upon the lawns of several old estates around Newark, where in some cases they are more numerous than in 1885. The woods around Newark are now brown from dying twigs, and one or two young peach orchards have been practically ruined. The injury is only local, however, and not serious generally. It was observed that the pupæ upon emerging from the ground were strongly attracted by an acetylene bicycle lamp. On changing its position the pupæ would at once turn toward the light, often going around a circle. Even their strong instinct for ascending the nearest tree was thus overcome, and in several instances those upon the base of the tree descended toward the light. Though I was unable to make a trial of it, this suggested that a bright light in the center of a sunken pan containing water and kerosene might make an efficient trap upon badly infested lawns.

During the season of 1901 the white-marked tussock moth and fall webworm were unusually injurious and seem to be almost equally so this year. The apple-tree tent caterpillar was more abundant this spring than for many years. Apples have been unusually injured by the plum curculio, eight or ten scars on an apple not being uncommon. Arsenical sprays seem to have no effect whatever in preventing this injury, apples being badly stung in an orchard which has been carefully sprayed for many years. On the same place, however, the fruit of an old cherry tree, which was formerly entirely destroyed by the curculio, is now untouched, owing to its being sprayed with arsenites and Bordeaux mixture.

Crambus caliginosellus continues to be one of our worst pests of young corn. *Systena tæniata* often destroys replanted corn and is our worst pest of newly set tomatoes, one for which we have as yet no very satisfactory remedy.

The strawberry weevil (*Anthonomus signatus*) was excessively injurious this year for the first time since 1898, and cut the early staminate varieties about one-third, and in some instances practically ruined the crop. A remedy for this pest would be of great value to berry growers, but it seems invulnerable to attack.

NOTES FOR THE YEAR IN NEW YORK.

By E. P. Felt, *Albany, N. Y.*

The season has not been marked by any unusual demonstrations by injurious insects, except in the case of a few species which will be noticed briefly.

The grape root-worm, *Fidia viticida* Walsh, has caused a great deal of injury in the Chautauqua grape belt during the last two years. It was estimated last spring that fully 80 acres had been practically destroyed by this insect and that at least 200 acres were more or less infested. Subsequent observations have shown that, in all probability, the infested area must be greatly extended. The insect has been so very injurious during the spring that certain vines which developed leaves in an apparently normal manner began to wilt about the middle of June and by the latter part of the month had died. This was attributed to the grape root-worm. The depredations appear to be more serious upon gravelly than upon heavy clay soil, and some recent experiments would appear to indicate that a considerable number of the pupæ may be destroyed by plowing the soil away from the vines and back while the insect is in this stage.

The grapevine leaf-hopper, *Typhlocyba comes* var. *vitis.*, has been exceedingly abundant and destructive in the Chautauqua grape belt last year and early this spring. It caused a great deal of injury in the fall of 1901, and present conditions are very threatening. This insect is now being investigated by Professor Slingerland of Cornell University.

The apple-tree tent caterpillar, *Clisiocampa americana* Fabr., has been conspicuous by its absence in certain portions of western New York. This is probably due, in some cases at least, to the very heavy snows of the preceding winter, which allowed mice free access to all roadside trees and shrubs, which were very largely girdled by these michievous rodents. It thus happened that the tent caterpillars found very little of their favorite food and undoubtedly many hatching on these unfortunate trees must have perished.

The forest tent caterpillar, *Clisiocampa disstria* Hubn., has been present in comparatively small numbers and its depredations during the last three or four years appear to be on the decrease. It is hoped that this year will see the end, for a time at least, of serious injuries by this pest.

The fall webworm, *Hyphantria cunea* Drury, has appeared in the State unusually early and indications are that it will be more destructive than usual.

OBSERVATIONS ON CERTAIN INSECTS ATTACKING PINE TREES.

By E. P. Felt, *Albany, N. Y.*

The work of several species of Tomicus has been very apparent in the Hudson River Valley during the last two or three years, and at our last meeting the writer placed on record his belief that species belonging to this genus were responsible for the destruction of many white pines in New York State. More extended observations have but strengthened that opinion, and this paper is really a continuation of the one published on pages 63–68 of our last proceedings.

One pine was found which bore no signs of injury, although its branches were sparse, which had been entered in large numbers by *Tomicus calligraphus* Germ. The needles were rather thin August 5, 1901, but practically none were brown, although pitch tubes were very abundant and many small masses of pitch had dropped upon the foliage of surrounding shrubs. At this time most of the beetles were running their primary galleries in the living bark along practically the entire length of the trunk and many eggs were being laid.

The next observation was made September 26, and then two-thirds of the needles were brown and the remainder were changing rapidly.

October 16 practically all the needles were brown and dead. The bark was entirely dead, moist, and its inner layers consisted of little else but decaying borings. Practically all of the living Tomicids had forsaken this tree, though some were found in one near by which had been less severely injured. The limbs were entirely bare of needles early in this spring.

This rapid destruction is also well shown in two other trees of which the writer possesses photographs. These pines had been under general observation for four or five years, and early in 1901 the foliage of the top of one may have been a little thinner than normal. This was noticed in particular August 5, at which time the lower limbs were nice and green, though the upper portion of the tree was then dead. An examination showed that the latter had been attacked by *Tomicus pini* Say. The work of *Tomicus calligraphus* in the living lower portion of the trunk was very evident at this time. *Monohammus confusor* Kirby was also very abundant about this tree. It had evidently bred in considerable numbers in the upper portion of the trunk and then attacked the lower part. The needles had practically all fallen from the upper limbs September 26, and those on the lower were brown and dead. Early in 1902 nothing but bare limbs remained. The companion in misfortune stood close by, and August 5, 1901, bore many pitch tubes above the middle, the work of *Tomicus calligraphus*. September 26 all its needles were browning fast, especially those of the lower limbs, and all were dead October 16. Its condition early in 1902 was the same as that of the trees described above. Both of the last mentioned had been attacked by *Dendroctonus terebrans* Oliv., but in small numbers, and most of the injury was undoubtedly caused by Tomicids.

The destructive work of *Tomicus pini* was further evidenced by a complaint from Jeremiah Day, of Catskill, N. Y., December, 1901, to the effect that 50 young white pines 25 or 30 years old had been killed during the preceding summer, and specimens of bark proved this species to have been the depredator.

The above shows how quickly a tree may die and lose its foliage in the Northern States. The dates given above indicate that a pine may be destroyed in about ten weeks. The rapidity with which such trees yield to the elements is well shown in this photograph, which represents a tree that was probably attacked early in 1900, because September 15, 1900, it was in a dying condition. *Tomicus calligraphus* was present in immense numbers at the base of the trunk and in smaller numbers higher up. *Tomicus pini* was found in the lower middle part of the trunk, in the upper portion, and also on the undersides of the limbs. It was found almost exclusively wherever the bark was too thin for the larger form.

The pines along the Hudson River Valley have suffered severely from these bark borers, which apparently have been the primary cause of the trouble. The reason for this outbreak is not known, although it possibly may have some connection with the great drought of the preceding years, which may have weakened the pines and rendered them easier victims of their insect enemies.

EGG-LAYING RECORD OF THE PLUM CURCULIO.

(*Conotrachelus nenuphar* Herbst.)

By A. L. Quaintance and Ralph I. Smith, *College Park, Md.*

The accompanying table requires but little in the way of explanation, aside from a statement of conditions under which the work was done.

On the morning of May 13, 1902, a considerable number of curculio were caught from Japan plum trees in the college orchard, by the usual jarring method. At this time egg laying had but just begun, as very few punctures were to be found in the young plums. Ten females were taken in copulation and each placed in a four-ounce bottle. Three or four fresh plums were supplied daily to each insect, and the number of eggs deposited was determined by dissection of punctures in the plums as removed. It was found necessary to examine each puncture carefully, as a considerable number of punctures and crescents were to be found in which no eggs were deposited. The bottles were kept rather loosely corked and bits of filter paper were placed in bottom of bottle to absorb any surplus moisture from the plums.

A review of the table shows that the greatest number of eggs deposited by any one beetle was 436, in the case of No. 5, with 276 as the minimum for No. 1, of practically the same age. It is also to be noted that the egg-laying period lasted for eighty days. The death of beetles Nos. 1, 5, and 9, about August 1, would indicate that females may live approximately twelve months and that the broods would overlap somewhat.

Table showing egg-laying record of the plum curculio (Conotrachelus nenuphar), 1902.

Date.	Curculio—									
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1902.										
May 14	2	4	0	9	8	7	0	3	8	4
15	0	10	0	3	4	5	0	3	1	10
16	8	6	0	9	12	12	2	10	13	9
17	7	9	0	9	12	9	0	3	10	9
18	6	12	0	9	10	10	3	6	9	13
19	5	12	0	8	9	11	3	7	8	13
20	9	12	0	15	15	10	9	13	16	13
21	15	9	0	17	17	11	8	11	16	13

Table showing egg-laying record of the plum curculio, etc.—Continued.

Date.	Curculio.—									
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1902.										
May 22	9	12	Male?	15	13	14	9	13	17	No p.
23	9	13	....	14	11	10	8	8	12	14
24	11	15	....	17	15	13	12	12	14	14
25	9	15	....	13	17	5	4	13	18	12
26	8	15	....	14	18	4	4	12	18	11
27	14	12	....	12	13	10	0	14	19	15
28	3	5	....	8	8	6	Died.	4	6	12
29	6	4	....	6	7	4	....	7	7	8
30	5	3	....	6	5	5	....	3	6	5
31	6	6	....	8	10	5	....	(*a*)	9	10
June 1	7	8	....	9	11	11	....	....	11	14
2	7	9	....	9	11	10	....	....	11	14
3	9	5	....	13	12	15	....	....	11	14
4	0	5	....	7	8	11	....	....	12	12
5	6	0	....	9	9	7	....	....	12	8
6	0	4	....	6	4	6	....	....	6	2
7	4	5	....	10	7	7	....	....	10	5
8	4	5	....	7	5	7	....	....	6	4
9	4	4	....	8	5	7	....	....	7	4
10	2	3	....	4	7	6	....	....	7	1
11	2	1	....	6	4	4	....	....	8	4
12	5	3	....	2	7	3	....	....	8	1
13	5	5	....	4	6	4	....	....	8	3
14	0	2	....	2	4	5	....	....	4	5
15	4	0	....	6	4	4	....	....	4	5
16	4	0	....	6	3	4	....	....	4	5
17	4	0	....	2	8	3	....	....	3	4
18	3	0	....	2	5	2	....	....	3	4
19	2	2	....	Died.	3	3	....	....	3	7
20	2	Died.	....	....	3	0	....	....	5	4
21	2	....	....	....	4	0	....	....	3	3
22	2	....	....	....	3	0	....	....	4	2
23	1	....	....	....	3	0	....	....	4	2
24	2	....	....	....	4	0	....	....	3	3
25	2	....	....	....	2	0	....	....	3	0
26	1	....	....	....	1	0	....	....	2	0
27	3	....	....	....	0	0	....	....	0	1
28	2	....	....	....	2	0	....	....	1	0
29	4	....	....	....	5	0	....	....	1	3
30	1	....	....	....	2	0	....	....	1	4
July 1	1	....	....	....	2	0	....	....	2	0
2	2	....	....	....	3	0	....	....	2	0
3	1	....	....	....	1	0	....	....	0	0
4	1	....	....	....	1	0	....	....	2	0
5	1	....	....	....	2	0	....	....	2	0
6	1	....	....	....	2	0	....	....	0	0
7	0	....	....	....	0	0	....	....	1	0
8	0	....	....	....	0	0	....	....	1	0
9	0	....	....	....	0	0	....	....	0	0
10	0	....	....	....	0	Died.	....	....	0	0
11	0	....	....	....	0	....	....	....	0	0
12	1	....	....	....	1	....	....	....	0	0
13	1	....	....	....	2	....	....	....	0	1

[a] Escaped.

Table showing egg-laying record of the plum curculio, etc.—Continued.

Date.	Curculio—									
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
1902.										
July 14	1	....	....	....	2	....	....	....	0	1
15	0	....	....	....	1	....	....	....	0	1
16	1	....	....	....	3	....	....	....	0	3
17	1	....	....	....	2	....	....	....	0	1
18	1	....	....	....	1	....	....	....	1	2
19	1	....	....	....	1	....	....	....	0	1
20	1	....	....	....	4	....	....	....	1	2
21	2	....	....	....	5	....	....	....	2	3
22	3	....	....	....	4	....	....	....	1	1
23	2	....	....	....	4	....	....	....	2	2
24	4	....	....	....	3	....	....	....	1	4
25	3	....	....	....	4	....	....	....	2	4
26	4	....	....	....	5	....	....	....	3	Died.
27	3	....	....	....	5	....	....	....	1	....
28	3	....	....	....	5	....	....	....	1	....
29	2	....	....	....	4	....	....	....	0	....
30	2	....	....	....	4	....	....	....	0	....
31	4	....	....	....	4	....	....	....	Died.	....
Aug. 1	3	....	....	....	5	....	....	....	....	....
2	Died.	....	....	....	Died.	....	....	....	....	....
Total	276	235	....	294	436	270	62	142	396	348

The following papers, which had been sent to the secretary, were read by title:

NOTES FROM NEW MEXICO AND ARIZONA.

By T. D. A. Cockerell, *East Las Vegas, N. Mex.*

Nothing especially remarkable has occurred in the field of economic entomology during the past year or two in this part of the country, but the following records are not without interest.

COCCIDÆ.

Parlatoria blanchardi (Targ.).—Professor Forbes (Johnson, Fumigation Methods, p. 229) has recorded the fumigation of about 400 date-palm suckers infested with Parlatoria. He determined, experimentally, that palms would stand a strong dose, and accordingly treated all those received at Tempe, Ariz., for the date-palm orchard of the Arizona experiment station. In the spring of the present year I inspected all these palms and found that the Parlatoria had been totally destroyed. Of course, there are parts of the palms which can not be examined without pulling them to pieces, but I feel quite sure that the Parlatoria would be in evidence upon the visible parts by this time if any had survived. On one palm I found a small quantity of *Phœnicococcus marlatti*, Ckll., alive and healthy.

APHIDIDÆ.

Chaitophorus negundinis Thomas, on box-elder, and *C. populicola*, Thomas, on narrow-leafed cottonwood, are common in Las Vegas, N. Mex.

LEPIDOPTERA.

Clisiocampa constricta Stretch.—The larvæ of this species defoliated great numbers of cottonwood at Tempe and Phoenix, Ariz., in March, 1902. They were full fed, spinning up at the end of March, and I noticed that they often wandered 100 yards or more from the trees. It would doubtless be easy to trap them at this time with gunny sacks tied around the trees. I bred several moths, but got no parasites. The larva is quite variable in its markings. I made the following notes at Tempe, March 29:

Larva, wandering, ready to pupate; 38^{mm} long (smaller ones, perhaps males, 27^{mm}); general color the usual light blue-gray, with long, white hairs, those on dorsum about 5^{mm}; a broad black dorsal band, constricted somewhat at the sutures, on each segment bearing many erect, rather short, orange-ferruginous hairs; sides minutely speckled with black; an elongated irregular subdorsal black mark on each side of each segment, its lower edge bordered by a small, pale mark; extreme sides with denser tufts of white hair; under surface black, clouded with gray; abdominal legs pale ferruginous apically; head spotted with black and beset with erect, black hairs. Other specimens have large more or less dumb-bell shaped orange dorsal patches, one on each segment.

COLEOPTERA.

Galerucella decora var. *salicis* Randall (det. Schwarz.), was found May 24, 1902, injuring willow in Gallinas Canyon, New Mexico, at a place called Trout Spring.

Lina scripta Fab., was found this year in Las Vegas, N. Mex., but it is rare and not destructive with us. Probably it has some natural enemy to keep it down.

Anthrenus scrophulariæ Linn. has been abundant this spring on flowers in Las Vegas. The first specimens were found by Miss Florence Mair, on flowers of cultivated Berberis.

Haltica foliacea Lec. (det. Fall), was found at the top of the Las Vegas Range, New Mexico, at about 11,000 feet, at the end of June, 1901. What could be its food plant at this altitude? Epilobium, perhaps.

Chrysobothris mali Horn. (det. Schwarz.), was received from Simmons, Ariz., where it was reported to have killed a two-year-old apple tree. The species was originally found infesting apple trees in California, but it has occurred also on native trees and shrubs (though not bred therefrom) and is presumably native. *See* Fall, Coleop. So. Calif. (1901), p. 117.

Diabrotica 12-punctata Oliv., occurs at Phœnix, Ariz., and is not replaced by *D. soror* until we reach California. From San Bernardino westward *soror* takes its place completely.

A PARTIAL LIST OF THE COCCIDÆ OF OHIO.

By F. M. Webster and A. F. Burgess, *Wooster, Ohio.*

In connection with the following list a short explanation is not inappropriate. The supervision of the work of nursery and orchard inspection was placed in the hands of Mr. Webster in 1900, and the original intention was to gradually collect as much data as possible while carrying out the work and later to publish a report that would be of service to the people and at the same time contain matter of value to the science of entomology. With the retirement of the board of control and the resignation of Mr. Webster, as well as the placing of the inspection work in the hands of the State board of agriculture, the original project had to be abandoned. But we have thought that the fragments obtained during this time were worth placing on record and whatever of value they might possess made available to other entomologists in Ohio or elsewhere. We do not present this as a complete list of the Coccidæ of Ohio, by any means, but rather as the possible basis for a better one, and which will, beyond a doubt, be the work of others than ourselves.

We are greatly indebted to Mr. George W. King and Prof. T. D. A. Cockerell, who made most of the determinations for us at the expense of much time and labor, and without their aid we should hardly have attempted the list at all. Dr. Howard and his assistants have also aided in the same manner. We have also included such species as were contained in Prof. Herbert Osborn's list, included in his "Remarks on the Hemipterous fauna of Ohio with a preliminary record of species" (Eighth Annual Report of the Ohio State Academy of Science, pp. 60–79, 1900), and also species collected by Professor Osborn's assistant, Mr. J. G. Sanders.

1. *Eriococcus azaleæ* Comst.	On *Rhododendron catawbiense,* Wooster, May 29, 1900 (Webster). This shrub was planted on north side of experiment station building, and the insect had withstood winter weather in the open.
2. *Gossyparia ulmi* Geoff.	On elm, Columbus, June 4, 1902 (Burgess).
3. *Phenacoccus osborni* J. G. Sanders	On *Platanus occidentalis*, Columbus (J. G. Sanders).
4. *Phenacoccus aceris* Sign.	On maple, New Philadelphia, July 13, 1900; Springfield, Oct. 3, 1901.
5. *Dactylopius citri* Bois.	Common in greenhouses.
6. *Dactylopius adonidum* Linn.	On roots of plum and Carolina poplar in insectary (C. W. Mally); feeding in insectary on canna, barberry, rose, onion, tobacco, and poplar (Wilmon Newell).
7. *Dactylopius longispinus* Targ.	In greenhouses.

8. *Kermes galliformis* Riley	On oak, Wooster, Sept. 29, 1899 (Wilmon Newell); see also American Naturalist, XV, p. 482, 1881.
9. *Kermes trinotatus* Bogue	On white oak, Georgesville (J. S. Hine).
10. *Orthezia americana* Walk. (?)	Georgesville (Fullmer). 8th Rep. Ohio State Academy of Science, p. 71.
11. *Orthezia insignis* Dougl.	Wooster; Columbus (Osborn). Common in greenhouses.
12. *Lecaniodiaspis celtidis* Ckll.	Sandusky (Osborn). Given in Rep. Ohio State Acad. Sci. Rep., p. 71, as a Lecanium.
13. *Asterolecanium variolosum* Ckll.	On *Quercus aurea*, Mentor, Feb. 7, 1900 (Wilmon Newell).
14. *Pulvinaria innumerabilis* Rath.	Common and sometimes injuriously abundant on maple; Wooster, July 2, 1901, on elm (Burgess); Shreve, July 5, 1901, on pear (Burgess).[a]
15. *Pulvinaria acericola* W. and R.	Cleveland, July 11, 1901, on maple. Columbus (Osborn).
16. *Eulecanium armeniacum* Craw	On Spanish chestnut, Painesville, Feb. 5, 1897 (Webster), on plum, Richland, June 28, 1900; on plum, Bowling Green; peach, Mentor (Burgess).
17. *Lecanium caryæ* Fitch	On American elm, Wooster, June 4, 1902 (R. L. Webster).
18. *Lecanium fletcheri* Ckll.	On *Thuja occidentalis*, Columbus, Feb. 27, 1902 (Sanders).
19. *Eulecanium oleæ* Bern.	Columbus (Osborn).
20. *Eulecanium cockerelli* Hunter	Lakeside, on peach, Dec. 1, 1900, and Shreve, on pear, July, 1901 (Burgess).
21. *Eulecanium fitchii* Sign.	On blackberry, Minerva; premises of H. H. Altfather.
22. *Eulecanium canadense* Ckll.	On American elm, Wooster, July 2, 1901 (Burgess).
23. *Eulecanium websteri* King	On mulberry, southern Ohio (Webster).
24. *Eulecanium tulipiferæ* Cook	On tulip trees, Wooster (Webster); on tulip trees, Cincinnati (Burgess); on same, Avondale (R. W. Braucher); on tulip tree, Lodi, Aug. 1, 1900; on tulip tree, Painesville, July 17, 1901 (Burgess); Warren, July 10, 1901; Weston, Sept. 19, 1898 (Webster).
25. *Eulecanium magnoliarum* Ckll.	On magnolia, Cincinnati (R. W. Braucher), Feb. 19, 1901.
26. *Eulecanium nigrofasciatum* Perg.	Wooster, Mar. 26, 1902 (R. L. Webster); Cleveland, Dec. 24, 1899, on Norway maple (Webster); Mansfield; Wellsville, Mar. 21, 1901.
27. *Eulecanium nigrum* var. *depressum* Targ.	On California pepper tree, Cleveland, Feb. 6, 1900 (Newell).

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[a] Young, probably of this species, were found on Virginia creeper, at Mentor, Nov. 2, 1901, by J. C. Britton. Immature specimens from maple, resembling a Lecanium but having the antennæ of a Pulvinaria, may, perhaps, prove to be a new species.

28. *Eulecanium persicæ* Fabr.	Syracuse (Osborn); Dresden (Webster); Norwalk, May 21, 1900, on nectarine.
29. *Eulecanium quercifex* Fitch	On oak, College Hill, May 22, 1900 (Webster).
30. *Eulecanium prunastri* Fonsc.	On plum, very abundant at Gypsum, 1900 (Webster).[a]
31. *Calymnatus hesperidum* Linn.	Wooster, in greenhouses on lemon, fig, cinnamon cassia (Webster); oleander.
32. *Saissetia hemisphæricum* Targ.	Wooster, insectary, on chrysanthemum, Sept. 17, 1897 (Webster); on *Pteris* sp? Jan. 1, 1900 (Newell); on *Crytomium balsatum* (Webster); Ashland, Mar. 10, 1897.
33. *Aspidiotus hederæ* var *nerii* Bouché	On yucca, Cleveland, Feb. 6, 1900; Cincinnati, Feb. 13, 1901, on palm; on oleander, Dayton, Aug. 12, 1901 (H. E. Maxwell); Columbus (Osborn).
34. *Aspidiotus juglans-regiæ* Coms.	On maple, Kinsey, Aug. 4, 1900 (Hine).
35. *Aspidiotus ostreæformis* Curtis	On plum, Danbury, Dec. 13, 1900 (Burgess); on snowball, linden, and ornamental maple, Cincinnati, Mar., 1901 (R. W. Braucher); on Carolina poplar, Cleveland, Apr. 4, 1901 (Webster); Massilon, Aug. 2, 1901 (Newell).
36. *Aspidiotus rapax* Comst.	On bay tree, greenhouses, Soldiers' Home, Dayton, Aug. 18, 1901 (Burgess).
37. *Aspidiotus perniciosus* Comst.	On all kinds of fruit trees except sour cherry; also on currants, gooseberries, strawberries, grapes, raspberry, blackberry, elm, maple (rarely), poplar, willow, catalpa, etc. There are over 125 infested localities known in the State.
38. *Aspidiotus aurantii* Maskell	On orange tree, June 30, 1902, Columbus (J. G. Sanders).
39. *Aspidiotus ancylus* Putn.	On currant, Bridgeport, 1895 (Webster) Clyde, Jan. 18, 1897; on *Cornus variegatus*, Cleveland, Feb. 7, 1900; on *Clethra alnifolia*, Painesville, July 17, 1900 (Burgess); on Norway maple, Perry, July 19, 1900 (Burgess); on quince, Lakeside, Nov. 15, 1900 (Burgess); on plum, Danbury, Dec. 1, 1900 (Burgess); on maple, New Antioch, Mar. 25, 1901. Occurs also on apple and peach, seldom in injurious numbers, and is general over the State.[b]

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[a] *Eulecanium* species not determinable from material at hand are as follows: On rose, Rumley; on peach, Lakeside (Burgess); on Osage orange, Lakeside (Burgess); on pear (George W. Gill), Columbus; on apple, Mentor (Burgess); on plum, Lakeside (Burgess); on quince, Lakeside. What is likely *E. pyri* Schr. was found at Shreve, July 5, 1901 (Burgess), but this should be verified.

[b] *Aspidiotus perniciosus* and *Mytilaspis ulmi* Linn. have been sent me intermixed on twigs of an unknown shrub, from Sandy Bay, near Hobart, Tasmania, by Mr. Horace Watson.—F. M. W.

40. *Aspidiotus forbesi* Johns.	On currant, Mertz, Apr. 12, 1896 (Webster); Frogys, Mar. 9, 1898, on cherry; on apple, Painsville, Aug. 22, 1900, (Burgess); on walnut, (J. C. Britton); Columbus (Osborn); Mentor, Cheshire, and elsewhere throughout the State, on cherry and old apple trees.
41. *Aspidiotus cyanophylli* Sign.	On *Pritchardia filifera* in greenhouse, Columbus (J. G. Sanders).
42. *Aspidiotus obscurus* Comst.	On oak, Catawba Island (W. H. Owen); on hickory, Danbury, Dec. 20, 1900; Columbus (J. S. Hine).
43. *Aspidiotus comstocki* Johnson	On maple, Columbus. See Bull. No. 6, N. S., U. S. Dept. Agr., p. 76 (W. G. Johnson).
44. *Aspidiotus uvæ* Comst.	On grapes, Cincinnati, Feb. 15, 1901 (Burgess); Pomeroy, Apr. 15, 1901; also on grape.
45. *Aspidiotus ficus* Ashm.	In greenhouses, Wooster (Webster); Columbus, in greenhouses (Osborn).
46. *Aspidiotus glanduliferus* Ckll.	On *Pinus sylvestris*, Columbus (J. G. Sanders).
47. *Aspidiotus crawii* Ckll.	On *Satania* sp.? McGregor's greenhouses, Springfield, Feb. 15, 1900.
48. *Chrysomphalus dictyospermi* Morg.	Columbus (Osborn).
49. *Chrysomphalus aonidum* Linn.	Reported from Ohio by Mr. Geo. B. King.
50. *Diaspis pentagona* Targ.	Painsville, introduced on double flowering cherry from Japan. Died out during winter of 1898–99 (Webster).
51. *Diaspis cacti* Comst.	In greenhouses, Columbus (Osborn).
52. *Diaspis boisduvalii* Sign.	On palm, Wooster, station greenhouse (Webster); on *Seafortia* sp.? Cincinnati, Eden Park conservatories, Feb. 19, 1900 (Newell); on palm, Columbus (Hine).
53. *Aulacaspis rosæ* Bouché	On rose, raspberry, blackberry, common, Wooster, Columbus, Mentor, New Carlisle, Berlin Crossroads, New Antioch, Perry, Portsmouth, Eaton, Cleveland, Toledo, Xenia, Fruit Hill, Cincinnati.
54. *Aulacaspis bromeliæ* Kerner	Columbus (E. E. Bogue).
55. *Parlatoria pergandei* Comst.	On Croton, Painsville, Sept. 22, 1900 (Webster); Columbus (Osborn).
56. *Parlatoria zizyphus* Lucas	On oranges in market, Columbus (Sanders).
57. *Mytilaspis linearis* Mod.	Reported from Ohio by Mr. Geo. B. King.
58. *Mytilaspis pomorum* Bouché	Abundant and destructive, especially in the northern parts of the State. Seems to be increasing in abundance and severity of injuries, especially on apple, Carolina and Lombardy poplars, willows, and lilac.
59. *Mytilaspis citricola* Pack.	On oranges in the markets. Not known as established in the State, in conservatories, and greenhouses.

60. *Mytilaspis ulmi* Linn.	On maple, Dayton, Aug. 19, 1901 (Burgess). Received from Sandy Bay, Tasmania, on apple (Webster).
61. *Chionaspis biclavis* Comst.	Columbus (Osborn).
62. *Chionaspis euonymi* Comst.	On althea sp? Spring Hill Cemetery, Cincinnati, Feb. 13, 1901 (Burgess).
63. *Chionaspis furfurus* Fitch	Generally distributed over Ohio on apple, pear, quince, and currant.
64. *Chionaspis pinifoliæ* Fitch	On *Pinus austriaca*, generally over the State where this pine is grown.
65. *Chionaspis corni* Cooley	Sandusky (Osborn).
66. *Chionaspis salicis-nigræ* Walsh	Not uncommon on willow; Wooster, June 14, 1901 (Burgess); West Carlisle, Oct. 4, 1901, on poplar (Burgess.)
67. *Chionaspis americana* Johns.	On *Ulmus americanus*, Columbus, Feb. 28, 1902 (J. G. Sanders).
68. *Chionaspis ortholobis* Comst.	On *Gleditschia triacanthos*, Columbus, Jan. 21, 1902 (Sanders).
69. *Howardia biclavis* Comst.	On *Hibiscus aculeatus*, Columbus (Sanders).
70. *Kermes andrei* King	On *Quercus prinus*, Columbus, May 30, 1902 (J. G. Sanders).
71. *Kermes pubescens* Bogue	On *Quercus macrocarpa*, Columbus, June 18, 1902 (J. G. Sanders).

OBSERVATIONS UPON THE MOSQUITO, CONCHYLIASTES MUSICUS.

H. A. MORGAN, *Baton Rouge, La.*

Along the creek bottoms of the uplands of Louisiana this mosquito is not uncommon, and in these regions is frequently called the "swamp mosquito," a name which is misleading, for in alluvial marshes and swamps it is seldom seen. The female is fierce in its attack upon mammals frequenting wooded regions in the vicinity of creeks. Marked swellings usually follow the attack upon man.

Nothing has been published relative to the life history of this mosquito. In fact, we are not aware of any observations upon the stages of its development save in the adult.

Dr. J. W. Dupree, of the city of Baton Rouge, captured April 30, 1902, a female which he permitted to feed upon his hand until fully engorged. On the morning of May 1, 40 eggs were found, some at the bottom of the glass containing the water, while others were resting upon some fibers of cotton which had accidentally fallen into the vessel. Dr. Dupree thinks it altogether likely that the eggs, which are deposited singly, under normal conditions rest upon floating débris. The eggs resemble somewhat in shape those of *Stegomyia fasciata*, though larger. Short spines pointing toward the so-called head of the egg are uniformly distributed over the entire shell. The egg has a flat and a convex surface, and with the latter uppermost presents a distinctly fusiform shape. Unless débris or a strong film floats upon the surface of the water, all the eggs sink to the bottom of the vessel, which accounts no doubt for the irregular periods of incubation. Of the 40 eggs deposited during the night of April 30 a few hatched on May 15, others hatched on May 30, and still others of the same brood on June 10. It will be seen from this that a wide range obtains as to the incubation period (from fifteen to forty days).

The larvæ are active at the surface of the water for the first twenty-four hours, after which they move to the bottom when disturbed, and can there remain as long as forty-seven minutes without coming to the surface for air. Larval growth is very rapid, most of the specimens bred reaching the pupa condition in five days (120 hours), though as long as seven days have been spent in this condition.

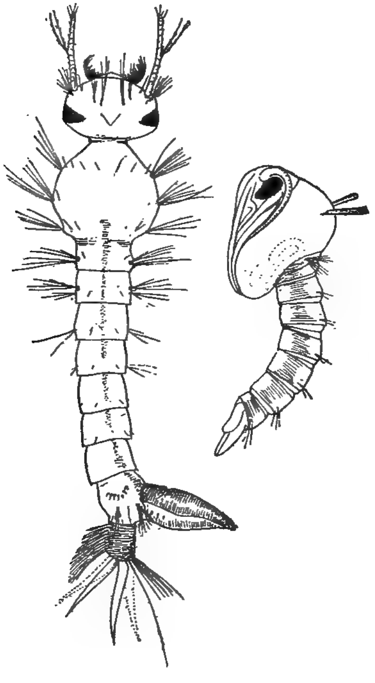

FIG. 1.—*Conchyliastes musicus:* egg, at left; larva, in middle; pupa, at right; all enlarged (drawn in Division of Entomology).

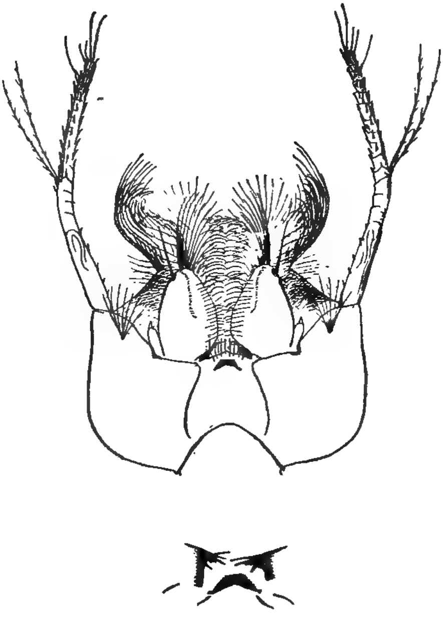

FIG. 2.—*Conchyliastes musicus:* head of larva above; inner mouth-parts of larva below; much enlarged (drawn in Division of Entomology).

The larvæ are not "wigglers" in the true sense of the term. They jerk characteristically when suddenly disturbed, but ordinarily move from the top to the bottom of the vessel at an angle of about 45 degrees with little motion save the rapid movement of the oral cilia. The passing of the larvæ from the top to the bottom of the water with apparently little effort gives them a graceful appearance. While at the bottom of the glass they catch large bundles of Spirogyra, which are broken into smaller pieces as the surface is approached. The vertices caused by the movement of the oral cilia bring the small pieces of food to the mouth. The pupæ are extremely sensitive, shifting position from the surface of the water with the slightest irritation. Length of pupal stage, twenty-four hours.

The peculiar conditions best suited for the development of this species of mosquito have not yet been found. Females fed in confinement upon the blood of mammals in most cases died in a few days without depositing eggs. Eggs procured in two instances were from females which were engorged with blood a few hours before oviposition.

To Dr. J. W. Dupree is due the credit for the information contained in the above article.

SOME NOTABLE INSECT OCCURRENCES IN OHIO FOR FIRST HALF OF 1902.

By HERBERT OSBORN, *Columbus, Ohio.*

The season is not far enough advanced to enable us to say what its character as a whole may be from the entomological standpoint, but already there have been several species appearing in such numbers as to attract more than usual attention.

The clover leaf-weevil, *Phytonomus punctatus*, has been unusually plentiful, and during the middle of May the larvæ were to be found in large numbers on the university farm. This is, I believe, the first time that this species has been destructively abundant in this locality. Its work will therefore be watched with interest, and it is to be hoped that it will repeat its usual history of being destructive for but one or two seasons.

The chinch bugs were flying in large numbers during the month of May, being especially conspicuous from the 15th to 20th. This abundance was to be looked for, as they were very plentiful last autumn and the winter was fairly favorable for their hibernation. Some reports of destructive work in wheat have been received, but since the heavy rains of early June these have been fewer, and there is perhaps no very serious outlook at present writing for the remainder of the season.

The cankerworm continues to be a menace to the orchards, and in many a very serious loss has occurred. There are a number of places near Columbus where this insect is defoliating the trees each spring; and while its work is much commented on at the time destruction is in progress, there seems a decided apathy on the part of a good many of the orchardists with regard to suppressing their onslaughts. In a number of places I have noticed their work also on elms, and the increase and spread of the species certainly merit all the attention they have received and a little more of vigorous treatment on the part of owners of orchards and timber plantations.

The horn fly, *Hæmatobia serrata*, has been noticed as very plentiful, perhaps not so abundant as during one or two summers after its first distribution, but in such numbers as to prove a serious annoyance to animals.

The fall webworm, *Hyphantria cunea*, has appeared in very great abundance and, it seems to me, much earlier in the season than usual. One colony was noticed in the latter part of May with larvæ already nearly grown, and during June numerous broods have been observed, some of which at present, June 26, appear to have completed their growth and entered the pupa stage. I have noticed the cuckoo feeding on the larvæ, tearing open the webs in order to get at them.

The occurrence which has doubtless attracted the most general attention and received the most extended popular notice is that of the periodical cicada, the eastern border of the brood passing just east of the city of Columbus.

The first occurrences noted in this locality were May 20, while reports indicated it two or three days earlier at Cincinnati. There seemed to be a fairly well marked early and later wave in appearance separated by a period of about two weeks, a second very abundant occurrence coming in early June. In an old orchard on the university campus this was particularly marked, as the early ones seemed to be completely destroyed by the attacks of the English sparrow so that at one time, about June 1, no individuals could be seen or heard, while the ground was completely littered with the wings and other fragments of the dismembered cicadas. The later appearing forms, while not so completely destroyed at that point, were, I think, mostly destroyed before they had succeeded in laying eggs, and for this particular spot it would appear as if there would be scarcely any to appear in another seventeen years. To some extent this is true of the wooded tracts near the city, but a few miles out I have noticed that the timber is pretty well marked with wilting leaves or drooping twigs which indicate the deposition of eggs.

A very noticeable feature, especially striking to me since I have never encountered it so conspicuously before, is the very large proportion of the small form of the cicada which has been recognized under the name of *cassini*. I have improved the opportunity to secure measurements of a large series, but this forms the subject of another paper and need not be further mentioned here.

An interesting occurrence noted this spring is *Gossyparia ulmi*, not hitherto recorded for Ohio, but found in sufficient numbers to be worthy of mention. As yet it can hardly be counted as of destructive abundance, but, taken with other coccids on the same tree, it must cause some injury.

A Pulvinaria has been observed as quite abundant on elms also, but lack of time has prevented any careful study of it.

Following the reading of these papers, they were opened for discussion.

Mr. Fisher asked how the cankerworm was most successfully treated. He stated that there was a very serious outbreak of the cankerworm in his orchard in Canada and that he had used bands, saturated with a castor oil and resin mixture, around the trees. Several thousand trees had been banded and on these trees, so far as he knew, there had been no cankerworms the present spring. It had required some time to inspect them and some experimentation was necessary before the effective proportion of the ingredients had been determined. It was extremely satisfactory as far as his experience had gone.

Mr. Quaintance inquired what proportion of oil and resin had been used, to which Mr. Fisher replied that 3 pounds of castor oil was used to 5 pounds of resin. The materials were warmed to thoroughly break up the resin, but were applied cold.

Mr. Osborn stated, in reference to the treatment of the cankerworm, that it was the practice to spray the trees with arsenate of lead or Paris green as soon as possible after the larvæ had made their appearance. He stated that at this time the insects were much more susceptible to treatment than later when the larvæ were more nearly full grown.

Mr. Smith stated that Dr. Howard had desired the observation of members in reference to the elm leaf beetle, and in regard to this insect he stated that it was more abundant in New Jersey the present year than for some time past. Four years ago there had been a great scarcity of the insect and two years before this it had not been necessary to do any spraying at all. Last year the insects began to increase to some extent and it was necessary to spray to destroy the larvæ. This year they were in large numbers and it had become necessary to spray while the beetles were feeding. By this means the beetles were largely killed off, but quite a number of larvæ had come through from the egg. In speaking further of shade-tree insects, Mr. Smith stated that the fall webworm promises to be more abundant in New Jersey this year than last. There had been a very great increase of this species the latter part of that year, and trees were considerably injured. The insects were not especially abundant in the early part of the season, but this year they had been destructive already. They had appeared so abundantly at the experiment station that he found it necessary to spray with arsenate of lead, and he thought, from the present condition, there would likely be a great increase of this species throughout the State before the season was out.

Mr. Felt spoke of the increase of this beetle and of the work of the green fruit worm.

Mr. Smith replied that he had not observed the green fruit worm to occur in New Jersey as a pest, but very early in the spring specimens had been sent him from a greenhouse man in Morris County. There were quite a number of specimens sent, and he had been informed that at various places there was a considerable amount of injury that had been done and was being done by this insect. Mr. Smith said he was much interested in the remarks of Mr. Sanderson concerning the chimney making of the periodical Cicada. He had never seen more perfect specimens than those exhibited by Mr. Sanderson, from Delaware.

Mr. Sanderson explained that these chimneys occurred only under buildings.

Mr. Scott at this point called attention to the coming meeting of the Association of Agricultural Colleges and Experiment Stations to be held in Atlanta, Ga., during October. He extended an invitation to the section of entomology and to the horticultural inspectors who might be present to take part in an excursion over the State, for which it was his desire to arrange.

Mr. Quaintance referred briefly to some of the entomological features in Maryland for the year. Attention was called to the strawberry beetle, which had been very abundant in the strawberry fields in Maryland and had cut off a considerable quantity of the bloom. The growers had estimated that from 35 to 50 per cent of the flowers had thus been cut off. At Greensboro and Ridgely they had adopted planting certain varieties which were very profuse bloomers, and the results were that the effect of the insect was rather beneficial than otherwise, as it tended to thin out the fruit, giving a better size and quality. Another insect that had proven to be somewhat injurious locally was the New York plum weevil. It had been reported by one orchardist as attacking the opening buds in the spring and doing considerable injury. Beetles were confined in breeding cages, and eggs and larvæ of the insect had been secured in considerable quantity. The eggs were deposited on leaves and protected by a fold. They were laid in masses of from 6 to 30. The larvæ inhabit the soil, immediately penetrating beneath as they hatch from the egg. They had been observed to feed on the roots of grass. Another insect that had been locally abundant was a species of grasshopper, *Melanoplus bivittatus.* An outbreak of this species occurred in Washington County, and it had been very injurious to clover. In one large field the clover crop had been largely destroyed. Adjacent to this field was a newly planted apple orchard, and the trees were doing nicely. The cutting of the clover forced the grasshoppers to the apple orchard, and the insects had attacked the trees, chewing the bark. In many cases the trees were entirely stripped of bark. The pea louse, which had been quite injurious in former years, was not now considered of great importance from the fact that growers planted only early varieties. The pea louse was not observed to be present in pea fields until after the middle of June. The fall webworm was quite abundant in Maryland this year, and was generally distributed all over the State.

Mr. Burgess stated that the plum curculio had done considerable injury to apples in northern Ohio the present year. The plum crop had also been severely injured.

Mr. Smith stated that there had been considerable injury in the southern part of New Jersey from the strawberry weevil, but it had not made its appearance in the northern part. While the injury had been rather extensive, he questioned if the loss had been of much real importance, owing to the beneficial effect of the thinning of the fruit. In reference to the pea louse, Mr. Smith stated that in the past some of the pea fields suffered quite a good deal, but up to this time in the present season the insects had not appeared in any number. A species of louse has been abundant on clover, but he did not learn of this until after the clover had been cut. He did not know whether or not there was any relation between the insect on clover and the pea louse.

Mr. Sanderson stated that the only information in reference to the occurrence of the pea louse in Delaware that had come to him was from reports, but it was his opinion that the insect had been of but little importance.

Mr. Hopkins inquired of Mr. Quaintance if the early planting of peas had been the result of entomological investigation.

Mr. Quaintance stated that he was not able to say, and referred the question to Mr. Sanderson, who replied that he did not know who had first suggested the plan of planting early varieties of peas to get around the injury from the pea louse. He thought that possibly it had been done by Professor Johnson. Mr. Sanderson stated that early peas both this year and last had been practically free from the insect. The remedy had been brushing, following by a cultivator, and in New Jersey a sprayer had been used.

Mr. Webster stated that the planting of early varieties of peas was the practice followed in Ohio.

Mr. Smith remarked that he had given the advice to plant early as soon as the life history of the insect had been worked out and in his first publication on the subject. In New Jersey he found it was safe to count on practical freedom from the insect until the middle of June.

Mr. Bogue, in speaking of the melon louse, thought that this insect could be readily killed by fumigation. He was much interested in the matter of parasites of this species. In regard to the grapevine-root worm, he thought that possibly the farmers had a remedy in the use of chickens which would help them some. Fowls had been used with good success with other insects. If the beetles were knocked off, he thought the fowls would destroy a great many of them.

Mr. Smith stated in reference to the melon aphis that fumigating with carbon bisulphid was common in New Jersey, and that a number of growers had a considerable supply of caps or covers for fumigating their vines. A close lookout is kept for the insect early in the season, and they endeavor to destroy the first infestation. Covers to the number of 10, 20, or even 50 were kept going for two or three days, and in this way all early infestation was destroyed.

Mr. Marlatt, referring to the reports on the periodical cicada, stated that the cicada turrets were very rare in Washington this year, and had only been found in a single instance. In this case they occurred in the woodshed of a gentleman living on Washington Heights, on the outskirts of the city. This woodshed had an earthen floor which was slightly moist, but not more so than the ground outside. The cicadas had come up in this shed in great numbers, and in every instance had built a turret varying in height from 1 to 6 inches. Without the shed the cicadas had come up in equal numbers, but through simple holes in the ground, without any sign of a turret. The explanation of the presence of the cicada turrets within this shed would be somewhat difficult. He had suggested that perhaps it was due to the darkness in the shed which led the cicadas to build their galleries above the surface of the soil in the effort to reach broad daylight.

Referring to the elm-leaf beetle, he said that Doctor Howard had already called attention to its practically complete absence in the elm grove on the grounds of the Department of Agriculture this year. This elm grove, he said, had been filled with beetles every year since he had been connected with the Department, and before it became the habit to have it properly sprayed the trees had been regularly defoliated. The complete absence of the insects this year was, therefore, rather remarkable. They were also very rare throughout the city, not doing more than one-tenth the damage of other years.

Mr. Hopkins stated that Doctor Felt's paper on pine insects had interested him, and it was his opinion that the collected beetles had not been the cause of the eradication of the insect the following year. This species is attacked by a parasite, *Bracon strobi*, which reduces it, and he thought probably this should be considered an important factor in their scarcity the following year. In regard to the pine Tomicus, Mr. Hopkins stated as a rule it would not attack perfectly healthy trees. In Germany there were two or three species regarded as injurious to pine forests. They prefer to attack injured trees, especially felled ones. He spoke of the new field of investigation to which he had been assigned with the Department of Agriculture—namely, the study of forest insects—and solicited the cooperation of entomologists of the different States and expressed his own desire to cooperate with the entomologists whenever possible. He considered that there was much room for original observation and thought much good would likely result from cooperative work.

Mr. Webster observed that the use of the term "States" he considered to be wrong. He thought too much distinction was drawn on State lines. Insects occur all over the country, and he thought life zones or geological boundaries were more proper terms to use. Mr. Webster further stated that refined kerosene had been used extensively in southern Ohio without injury to apple trees, but applied in less quantities in other parts of the State trees had been killed. He spoke of the need of investigation of the effect of mineral oil upon plants. He thought there were factors that were not understood.

Mr. Smith remarked that he agreed with Professor Webster in reference to the word "State," but it served in another way to express the actual facts that different workers had obtained varying results, and was really a designation of a worker in any given State.

Mr. Sanderson called attention to the fact that a record of the weather as made by the Weather Bureau was conducted somewhat along this line. He stated that he had had occasion to look up the weather record, and was able to secure the data from the State bureau.

Mr. Smith stated that in New Jersey there was a tabulated record for every locality at which a station is established, and that he was thus able to secure the weather record for ten or more years back without much trouble.

Mr. Hopkins observed that in West Virginia he had concluded it was not safe to base conclusions on the work of voluntary weather observers. Stations were at different elevations along the line, east and west. He considered the influence of climate as shown by the difference in flowering periods of plants to be of considerable use in this connection.

The president called attention to the matter of a small assessment of the members present to meet the current expenses of the secretary, and on motion it was voted to assess each member 50 cents.

It was voted to hold the next meeting at the same place of meeting of the American Association for the Advancement of Science, namely, Washington, D. C. After some discussion as to the exact date of meeting, it was voted to leave this to the officers of the association, the date to be announced by the secretary in the preliminary notice.

The meeting then adjourned.

CALLED MEETING, SATURDAY, JUNE 28, 1902.

A called meeting of the association was held in the Schenley Hotel, June 28, at 5 p. m., to consider the matter of electing representatives to the council of the American Association for the Advancement of Science, the association being entitled to this representation. Mr. Hopkins moved that two fellows be elected to the council, and a ballot was taken, with the result that Mr. A. D. Hopkins and Mr. C. L. Marlatt were elected.

A. L. QUAINTANCE, *Secretary.*

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Whitehead, Charles, Barming House, Maidstone, Kent, England.

CONSTITUTION, ASSOCIATION ECONOMIC ENTOMOLOGISTS.

This association shall be known as the Association of Official Economic Entomologists.

Its objects shall be: (1) To discuss new discoveries, to exchange experiences, and to carefully consider the best methods of work; (2) to give opportunity to individual workers of announcing proposed investigations, so as to bring out suggestions and prevent unnecessary duplication of work; (3) to suggest, when possible, certain lines of investigation upon subjects of general interest; (4) to promote the study and advance the science of entomology.

The membership shall be confined to workers in economic entomology. All economic entomologists employed by the General or State governments or by the State experimental stations, or by any agricultural or horticultural association, and all teachers of economic entomology in educational institutions may become members of the association by transmitting proper credentials to the secretary and by authorizing him to sign their names to this constitution. Other persons engaged in practical work in economic entomology may be elected by a two-thirds vote of the members present at a regular meeting, and shall be termed associate members. Members residing outside of the United States or Canada shall be designated foreign members. Associate and foreign members shall not be entitled to hold office or to vote.

The officers shall consist of a president, two vice-presidents, and a secretary, to be elected annually, who shall perform the duties customarily incumbent upon their respective offices. The president shall not hold office for two consecutive terms.

The annual meeting shall be held at such place and time as may be decided upon by the association at the previous annual meeting. Special meetings may be called by a majority of the officers, or shall be called on the written request of not less than five members. Eight members shall constitute a quorum for the transaction of business.

The mode of publication of the proceedings of the association shall be decided upon by open vote at each annual meeting.

All proposed alterations or amendments to this constitution shall be referred to a select committee of three at any regular meeting, and, after a report from such committee, may be adopted by a two-thirds vote of the members present: *Provided*, That a written notice of the proposed amendment has been sent to every voting member of the association at least one month prior to date of action.

BY-LAWS.

ARTICLE I.—*Of members.*

SECTION 1. The classes of members are defined in the constitution, as are their rights to vote or hold office. Members of all kinds have equal privileges as to presentation of papers and in the scientific discussions at the regular meetings, and may, by permission of the presiding officer, speak on business questions before the association.

SEC. 2. All members have equal rights to the published proceedings of the association and to any publications controlled by or distributed by the association, save that should any publications of economic interest be distributed by the association the distribution lists furnished by the active members are first to be regarded.

ARTICLE II.—*Of officers and their duties.*

SECTION 1. It shall be the duty of the president, in addition to the ordinary duties of a presiding officer, to prepare and deliver an annual address, to be delivered at the annual meeting over which he presides.

SEC. 2. It shall be the duty of the secretary to provide the necessary stationery and such books as he may be directed to provide, the expenses for which shall be met by an assessment of not less than 25 cents on the members in attendance at the meetings. The sum so collected shall be used by the secretary to reimburse himself for advances made and to meet the ordinary expenses of the association. An account shall be rendered at each annual meeting, and, if needed, an additional assessment shall be imposed.

SEC. 3. All officers shall be elected by ballot after open nomination, and this by-law shall not be suspended except by unanimous consent of the voting members present.

ARTICLE III.—*Of meetings.*

SECTION 1. Notice of the time and place of meetings shall be published in all the American entomological periodicals and in Insect Life.

SEC. 2. Special meetings shall be called as provided for in the constitution, and notice of such meetings shall be given by the secretary by mailing to each voting member a formal specification of the time and place of meeting at least two weeks before the date fixed in the notice. The notice shall state the reason for such meeting, and shall specify the business to be transacted, and no other business shall be transacted.

SEC. 3. The order of business at regular meetings shall be, at the first session:

(1) Calling the meeting to order by the president.
(2) The annual address by the president.
(3) Reports of officers.
(4) Reports of committees.
(5) Proposal and election of members.
(6) Written business communications.
(7) Verbal business communications.
(8) New business.
(9) Programme of papers and discussions.
(10) Adjournment.

At the following sessions:

(1) Reading and action on the minutes of previous meetings.
(2) Unfinished business.
(3) Proposal and election of members.
(4) New business.
(5) Programme of papers and discussions.
(6) Adjournment.

At the last session of the meeting the order of business shall be as at other sessions, except that after order (5) will come:

(6) Election of officers for the next meeting.
(7) Fixing time and place of next meeting.
(8) Reading and action on rough minutes of the entire session.
(9) Final adjournment.

ARTICLE IV.—*Amendments to by-laws.*

SECTION 1. Changes in these by-laws may be made at any regular meeting in the same manner and on the same notice as prescribed in the constitution for amendments to that instrument.

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SEVENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

CONNECTICUT

FOR THE YEAR 1907

BY

W. E. BRITTON, PH.D.

State Entomologist

New Haven, Conn.
1908

PART V.

SEVENTH REPORT

OF THE

STATE ENTOMOLOGIST OF CONNECTICUT

To the Director and Board of Control of the Connecticut Agricultural Experiment Station:

I hereby transmit my seventh report as state entomologist, according to Section 4387 of the General Statutes. As all state reports are to be published biennially hereafter instead of annually, technically this is Part V. of the biennial report. The financial and other administrative details are herein omitted, but will be published at the end of the biennial period.

Respectfully submitted,

W. E. BRITTON,
State Entomologist.

During the calendar year of 1907 the members of the office force have made thirty-one nursery inspections, thirty-one inspections of orchards, gardens and greenhouses, have written 1,156 letters regarding matters pertaining to the work of the department, sent out sixty-eight packages by mail and express, and have given eight addresses and lectures at agricultural and scientific meetings.

The state entomologist has been ably assisted throughout the year by Mr. B. H. Walden as general assistant, who has been in charge of the office in the absence of the entomologist; by Mr. George H. Hollister as local superintendent in charge of gypsy moth work at Stonington; and by Miss Elizabeth B. Whittlesey, who has worked as stenographer for half of each day.

ENTOMOLOGICAL FEATURES OF 1907.

Entomologically, the most interesting feature of the season was the outbreak of the peach sawfly in an orchard at Yalesville. This insect proved to be a new species, which has been described as *Pamphilius persicum* by Dr. A. D. MacGillivray, and was so abundant as to threaten the defoliation of a large number of trees. Consequently the owners sprayed between four and five thousand trees with lead arsenate, with satisfactory results. Mr. Walden has made a careful study of this insect, an account of which appears elsewhere in this report.

Good progress has been made in controlling the gypsy moth, which was discovered in Stonington last year. (See Report for 1906, p. 235.) Over 13,000 trees were banded in 1907 as against 1,300 the previous season, and though twice as many men were employed and much scouting done, only 2,936 caterpillars were found in 1907 where 10,000 were taken in 1906. The work was also strengthened and supported by an act of the legislature giving authority and making an appropriation. This entire matter is treated in detail on another page of this report.

The fall canker worm, *Anisopteryx pometaria* Harris, was more abundant at the station than since 1900, and the large number of males clustering on the trunks of trees on warm days in November and December indicate that this species will be even more abundant and destructive in 1908.

The spiny elm caterpillar, *Euvanessa antiopa* Linn., and the apple leaf miner, *Tischeria malifoliella* Clem., which were so common in 1906, did little damage in 1907.

The apple aphis, *Aphis pomi* DeGeer, was quite injurious, especially to nursery and newly set orchard trees, and in several cases spraying was necessary to prevent a marked checking of the growth.

The hickory tussock moth, *Halisidota caryae* Harris, was more abundant than for several years, and the caterpillars were found feeding upon apple, hickory and a number of other trees. A separate illustrated article treating of this insect is printed on a later page of this report.

In spite of an extreme drought extending through July and August, mosquitoes were exceedingly abundant and annoying in certain localities, and many complaints were received regarding them. In compliance with a request, the region about Niantic and Crescent Beach was examined for breeding places, and the report is published on a subsequent page of this pamphlet.

The grape vine flea beetle, *Haltica chalybea* Ill., was received from several localities, where it was reported as eating holes in the buds of the grape vine before the leaves unfold.

The winter of 1906-1907 was more severe than the preceding winter, consequently a smaller proportion of San José scales survived. While the increase and spread of this insect was less marked than in 1906, nevertheless it multiplied rapidly late in the season of 1907.

NURSERY INSPECTION.

This work was commenced the first week in September and was nearly completed November 1st, the last inspection being made November 8th. The inspections were made by Messrs. Britton, Walden and Hollister, Mr. Hollister being taken from the gypsy moth work for two months for this purpose. Including one spring inspection, thirty-seven nurseries have been inspected and thirty-six certificates granted during the calendar year. Five firms have gone out of business and four new nurseries have been started. On the whole, the nurseries were in better condition than last season, and much less stock had to be destroyed on account of scale. Many nurseries, however, are curtailing their supply of fruit trees and are growing more and more ornamental stock of such kinds as are not affected by scale. There is also a decided change for the better in the care given the nursery stock by the owners, though a few nurserymen are still careless. A few years ago it was not considered practicable to spray any nursery stock; usually the owners preferred to destroy it. Several nurserymen, following our directions, during 1906 to 1907 have sprayed their growing stock as a measure of safety, using either lime and sulphur or one of the miscible oils. The results have been very satisfactory, it being certain that a much greater degree of infestation would have occurred on untreated stock. The miscible oils are especially convenient for this purpose and do not discolor the trees.

A bill was introduced into the legislature providing for slight changes in the insect pest law, but the matter was opposed at a hearing before the agricultural committee, which reported adversely upon it. The law therefore remains as before.

The nursery firms receiving certificates in 1907 are as follows:

LIST OF NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1907.

Name of Firm.	Location.	Inspection Finished.	Certificate Number.
Atwater, C. W.	Collinsville	Oct. 2,	254
Barnes Bros. Nursery Co.	Yalesville	Oct. 14,	263
Beattie, William H.	New Haven	Oct. 4,	257
Bowditch, J. H.	Pomfret Center	Oct. 18,	267
Brainard, Chester F.	Thompsonville	Sept. 14,	249
Burr & Co., C. R.	Manchester	Oct. 9,	260
Comstock & Lyon	Norwalk	Nov. 6,	278
Conine Nursery Co., The F. E.	Stratford	Sept. 26,	251
Conn. Agricultural College	Storrs	Oct. 29,	274
Conway, W. B.	New Haven	Oct. 5,	258
Dehn & Bertolf	Greenwich	Oct. 17,	265
East Rock Park Nursery	New Haven	Oct. 4,	256
Elizabeth Park Nursery	Hartford	Nov. 13,	280
Elm City Nursery Co.	New Haven	Sept. 9,	247
Gardner's Nurseries	Cromwell	Nov. 19,	279
Gurney & Co., H. H.	New Canaan	Oct. 11,	261
Hale, J. H.	So. Glastonbury	Oct. 23,	270
Holcomb, Irving	Granby	Oct. 24,	271
Houston & Sons, J. R.	Mansfield Depot	Oct. 29,	275
Hoyt's Sons Co., Stephen	New Canaan	Oct. 11,	262
Hubbard & Co., Paul M.	Bristol	Oct. 17,	266
Hunt & Co., W. W.	Hartford	Nov. 1,	276
Kelsey & Sons, David S.	West Hartford	Sept. 28,	253
Keney Park Nursery	Hartford	Nov. 13,	281
Malone, Geo. W.	Highwood	Sept. 26,	250
Norton, A. F.	New Britain	Oct. 25,	273
Pierson, A. N.	Cromwell	Oct. 7,	259
Platt Co., The Frank S.	New Haven	Sept. 28,	252
Purinton, C. O.	Hartford	Nov. 5,	277
Ryther, O. E.	Norwich	Oct. 25,	272
Scott, J. W.	Hartford	Oct. 15,	264
Sierman, C. H.	Hartford	Oct. 4,	255
Vidbourne & Co., J.	Hartford	Sept. 10,	248
Woodruff, C. V.	Orange	Oct. 23,	268
Woodruff & Sons, S. D.	Orange	Oct. 23,	269

TESTS OF VARIOUS GASES FOR FUMIGATING NURSERY TREES TO DESTROY SAN JOSÉ SCALE.*

The object of the tests herein described was to ascertain if there is any gas that can be used more conveniently than hydrocyanic acid gas, especially in fumigating small lots of trees, cions and budsticks. For this purpose the materials must be reasonably inexpensive, the gases easy to generate, the apparatus simple, and the operation comparatively free from danger to the operator as well as harmless to the trees.

The writer was assisted in the chemical part of this work by Mr. F. H. Heath, a graduate student in chemistry in Yale University; and by Mr. B. H. Walden, who did most of the fumigating work.

Some orchardists and nurserymen are considerably prejudiced against fumigating trees with hydrocyanic acid gas. This prejudice is not well-founded though it must be admitted that many trees have been injured by leaving them too long in the fumigating house, and by attempting to fumigate them when wet. When properly done according to the methods usually recommended, no injury results. This has been proven over and over again, not only in our own experiments, but also in the tests made by other entomologists.

In a large fruit nursery where most of the stock is dug in the fall and not sent out until the following spring, it is an easy matter to fumigate the stock before heeling it in on the grounds. But it often happens that a customer calls for two or three trees which have not been dug or fumigated. The nurseryman dislikes to turn away a customer, and if possible will furnish the stock desired. Of course each well-equipped nursery should have small fumigating boxes in which a few trees or shrubs can be treated, in addition to the large fumigating house. But most of them have only the large house, and it is very expensive to charge it with gas for only a few trees. Some of the small nurseries are not provided with any sort of fumigating house. It is rather difficult for the average nurseryman to weight out the small quantity of cyanide necessary to use in a small box because he is not equipped with sensitive scales or balances for the purpose. If some volatile liquid could be used that he could measure in a glass cylinder, it would obviously be a much more simple and convenient matter.

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* A brief abstract of this paper was given at the meeting of Economic Entomologists at Chicago, December 27-28, 1907, and will be published in the Journal of Economic Entomology.

For the purpose we therefore selected carbon disulphide and carbon tetrachloride for volatile liquids, and sulphuretted hydrogen and chlorine for gases generated by chemical action. In order to make comparisons, a few tests were made with hydrocyanic acid gas, and untreated trees were kept as checks.

The trees were fumigated in a long narrow box containing ten cubic feet of space. In order to ensure a more uniform distribution of the gas, two generating dishes were used, one being placed near each end. The liquids were volatilized in shallow pans placed upon crossboards near the top of the box and above the trees. For the other materials deeper generators were necessary, and ordinary pudding dishes served the purpose nicely. A piece of glass was set in each end of the cover so that the action of the materials in the generating jars could be watched from outside.

As some of these materials were being used in this work for the first time, no data were available as a basis from which to compute quantities. In some cases Mr. Heath figured out the quantities of chemicals necessary to generate a volume of gas sufficient to fill the box if all the air was displaced. We could then divide these amounts by two or by four, as seemed best.

With carbon disulphide we had, of course, Smith's* and Garman's† experiments in destroying the melon aphis and the experiments of various entomologists in fumigating stored grains to guide us. The writer once purchased some plants of red-twig dogwood for the garden, and when delivered at the house they were found to be slightly infested with San José scale. The plants were placed in one of the set laundry tubs in the cellar, an unmeasured quantity of carbon disulphide poured in, and the whole tightly covered for about twenty-four hours.

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* New Jersey Agricultural Experiment Station Bull. 109, p. 32, 1895, and 121, p. 11, 1897.

† Kentucky Agricultural Experiment Station Bull. 53, p. 144, 1894.

The plants were then set in the garden, grew well, and showed no sign of scale during the season, or of injury from the treatment. However, with some of the gases it was necessary to guess at the quantities, but we sought to kill the scale, and expected that many of the trees might be injured. I am now convinced that further tests with some of the gases, especially carbon tetrachloride, in smaller quantities are desirable.

Baldwin apple and peach of several standard varieties were the trees used. All were more or less infested with San José scale, though none so badly as to seriously affect their vitality. Both roots and tops were fumigated, the trees properly labeled and planted in nursery rows on the station grounds, where they could be watched during the season. In all 359 trees were treated. The following table shows the number treated by each kind of gas:

	Apple	Peach
Carbon disulphide	59	61
Carbon tetrachloride	47	60
Sulphuretted hydrogen	10	15
Chlorine	25	22
Hydrocyanic acid gas	20	40
Total	161	198

The details of each test, with results, are given in the following descriptions and tables.

VOLATILE LIQUIDS.

Carbon Disulphide.

Carbon disulphide (CS_2) is a heavy liquid having a specific gravity of 1.29 and a boiling point of 115° F. The vapor is inflammable, and ignites in air at about 300° F. It is 2.63 times as heavy as atmospheric air, and one volume of the liquid evaporates to make about 375 volumes of vapor. Pure carbon disulphide is colorless and has no unpleasant odor, but the commercial article has a yellowish color and an extremely disagreeable odor, both of which are due to impurities which enhance its poisonous qualities.* The price varies from fifteen to twenty cents per pound, but it is cheaper in large quantities.

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* Farmers' Bulletin 145, U. S. Dept. of Agr., Washington, D. C., 1902.

Preliminary tests showed us that this liquid does not volatilize very readily at ordinary temperatures. Where large quantities are used this is quite a serious objection, as it not only requires a long fumigation period, but there is less certainty regarding the period in which the effect of the full amount of material is acting upon the scale and upon the trees. If trees with naked roots are exposed for too long injury will result from drying. It was suggested that this difficulty might be obviated by volatilizing the liquid in heated pans. Therefore heavy cast iron stew pans or "spiders" were used as generating dishes, these holding the heat much longer than thin ones stamped out of sheet steel. After heating to nearly 200° Fahr. one was placed near each end of the box above the trees. Small holes through the cover of the box enabled us to pour the liquid through a funnel directly into the heated dish. The holes were stopped with corks, and the carbon disulphide, which could be observed through the glass in the cover, volatilized in a few seconds or minutes, according to the quantity. Without the heated dishes, several hours were necessary in some cases. The quantities of materials used, length of fumigating period, and the effect upon scales and trees are given in Table I.

Results with Carbon Disulphide.

The smallest quantity used (10 fluid ounces per 100 cubic feet) did not kill all of the scales in a fumigation period of one hour. Where the heated dish was used to volatilize the liquid, 4.3 per cent. of the scales survived the treatment. Where the dish was not heated 19.2 per cent. came through alive, but one-third of the carbon disulphide was left in the dish at the end of the hour, so that much less of the vapor really acted upon the scales. All scales were killed in each of the other tests. It is to be regretted that this small quantity of disulphide was not given a two-hour period in one or more tests. One tree in Experiment No. 3 failed to grow, but this probably has little connection with the fumigation, as no other trees were injured until they were given three times the amount of liquid and four times as long a fumigation period. Moreover, untreated trees often die when transplanted. When the liquid equalled or exceeded thirty fluid ounces for one hour, some of the trees were

TABLE I.—CARBON DISULPHIDE.

No. Expt.	Fluid ounces of liquid used for 100 cu. feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
3	10 fluid oz.	1 hour	1 heated dish	5	5	4	87	4.3	9	1	Peaches looking good. 4 apples looking good, 1 started but died back.
7	10 "	1 "	1 unheat'd dish*	5	5	23	96	19.2	10		All trees making fair growth.
5	20 "	1 "	1 heated dish	5	5	0	all	0	10		" " "
8	30 "	1 "	1 "	5	5	0	"	0	10		Peaches made good growth. 3 apples looking good, 2 died back considerably at tops.
9	30 "	2 "	1 "	5	5	0	"	0	10		4 peaches died back considerably at tops. 1 apple " " " 4 looking good.
12	30 "	4 "	1 "	5	5	0	"	0	8	2	4 peaches with poor growth, 1 dead. 2 apples " " " 1 "
13	60 "	3 "	2 "	5	5	0	"	0	3	7	1 peach making good growth, 4 dead. 2 apples with poor growth, 3 dead.
14	40 "	2 "	2 "	4	5	0	"	0	8	1	1 peach made good growth, 3 started low, 1 dead. 4 apples made fair growth.
15	60 "	2 "	2 "	5	5	0	"	0	5	5	4 peaches dead, 1 with poor sprout. 1 apple dead, 3 started low, 1 with weak sprout.
16	80 "	2 "	2 "	5	4	0	"	0	2	7	2 peaches made fair growth.
29	40 "	4 "	2 "	5	7	0	"	0		12	All trees dead.
31	40 "	3 "	2 "	5	5	0	"	0		10	" " "

* About ⅓ of liquid left in dish.

injured, and in some cases forty ounces for two hours killed all of the trees, though in other instances some trees survived even a larger quantity. It is quite possible that a longer period with the smallest quantity would have given satisfactory results.

Carbon Tetrachloride.

Carbon tetrachloride (CCl_4) is a clear, colorless liquid having a specific gravity of 1.63 and a boiling point of 169° F. It has a pleasant odor somewhat resembling that of chloroform, and its vapor is non-inflammable and less poisonous than that of carbon disulphide. Carbon tetrachloride is used chiefly as a solvent and costs about forty cents per pound, though in quantities it can be purchased at a much lower price. Heated pans were used to volatilize this gas, and the quantities used, fumigation period, and results are shown in Table II.

Results with Carbon Tetrachloride.

As carbon tetrachloride killed all of the scales in each of the tests made, it is probable that even smaller quantities would have answered quite as well. At the rate of forty fluid ounces per 100 cubic feet of space for two hours, some of the trees failed to grow, and all larger quantities produced similar results. Thirty fluid ounces appears to be about the maximum limit of safety, and further trials should be made with smaller quantities of liquid and shorter periods of fumigation. As regards convenience, this material is very promising, as it is not dangerously poisonous to breathe in small quantities nor liable to explode, though more expensive than carbon disulphide.

GASES GENERATED BY CHEMICAL ACTION.

Sulphuretted Hydrogen.

Sulphuretted hydrogen or hydrogen sulphide (H_2S) is an invisible gas generated in our experiments from iron sulphide and sulphuric acid. It is 1.19 times heavier than air. It has a disagreeable and distinctive odor, and is very poisonous, although on account of the odor its presence can be detected at once. Sulphuretted hydrogen is given off from spoiled eggs, and to some extent from the lime and sulphur mixture.

TABLE II.—CARBON TETRACHLORIDE.

Expt. No.	Fluid ounces of liquid used for 100 cu. feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
35	10 fluid oz.	2 hours	2 heated dishes	5	5	0	all	0	10		All peaches making good growth. All apples " " "
38	10 "	6 "	2 "	5	5	0	"	0	10		3 peaches making good growth, 2 started low. All apples making fair growth.
39	20 "	4 "	2 "	5	5	0	"	0	10		3 peaches making good growth, 1 fair growth, 1 started below bud. All apples making fair growth.
37	30 " *	2 "	2 "	5	5	0	"	0	10		4 peaches making good growth, 1 started below bud. All apples making good growth.
18	40 "	2 "	2 "	0	10	0	"	0	8	2	4 peaches made good growth, 1 poor, 3 started below bud, 2 dead.
10	40 " †	3 "	1 "	5	5	0	"	0	9	1	3 peaches made good growth, 1 fair, 1 dead. All apples made fair growth.
11	40 "	3 "	2 "	5	5	0	"	0	3	7	1 peach started below bud, 4 dead. 1 apple made fair growth, 1 poor, 3 dead.
20	60 "	2 "	2 "	5	5	0	"	0	5	5	1 peach with thrifty sprout, 3 started below bud, 1 dead. 1 apple.
17	60 "	3 "	2 "	2	5	0	"	0	1	6	1 peach started below bud. All the other trees dead.
28	80 " ‡	2 "	2 "	5	5	0	"	0	1	9	1 peach with a good sprout, 4 peaches dead. 5 apples dead.
19	80 " §	3 "	2 "	5	5	0	"	0	4	6	All peaches dead. 4 apples with poor growth, 1 dead.

* Dishes heated only to 96°F. About 5 oz. left in one dish.
† " " " 150°. " 25 " " "
‡ About 15 oz. left in dishes. § About 23 oz. left in dishes.

The sulphide of iron used is in the form of hard lumps made by crushing the fused mass or slag. It is quite porous, which facilitates the generation of the gas. It should be crushed fine before use. Iron sulphide costs from eight to ten cents per pound.

Commercial sulphuric acid contains about ten per cent. of water, and costs about five cents per pound in nine pound bottles. Complete data regarding the tests with this gas appear in Table III.

Results with Sulphuretted Hydrogen.

All scales were killed by this gas and some of the trees receiving the largest and smallest quantities died, though for some inexplicable reason an intermediate amount produced no injury. The method of generating this gas is too slow to render it a convenient fumigating agent, even if it did not injure the trees. Possibly some easier and more satisfactory arrangement could be devised.

Chlorine.

Chlorine (Cl) is a heavy greenish gas with a pungent odor, and is not only poisonous but extremely irritating to the mucous membrane. It is about 2.5 times heavier than air, and is prepared by treating ordinary chloride of lime or bleaching powder with commercial sulphuric acid. Bleaching powder costs about five cents per pound.

Table IV. presents all of the statistics connected with the chlorine tests.

Results with Chlorine Gas.

As perhaps might be expected with chlorine, all of the scales were killed and most of the trees died also. This gas is altogether too inconvenient, too disagreeable and too destructive to trees to be of any value in fumigating work. A peculiar effect was noticed on those trees which survived the treatment. Nearly all buds were killed, and the bark was injured and discolored for half an inch or so each way from the bud, as if the gas entered through the bud and damaged the surrounding wood. The discoloration was apparent in some cases when the trees were removed from the fumigating box.

TABLE III.—SULPHURETTED HYDROGEN.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
1	25.1 lbs. 260 fl. oz. Sul. Acid 170 " Water	1 hour	1 dish	0	5	0	all	0	2	3	2 made fair growth.
2	12.5 lbs. 170 fl. oz. Sul. Acid 70 " Water	1 "	2 "	5	5	0	"	0	10		All making fair growth.
4	5 lbs. 80 fl. oz. Sul. Acid 50 " Water	1 "	2 "	5	5	0	"	0	8	2	Peaches looking fair. 2 apples looking fair, 1 with poor growth, 2 dead.

TABLE IV.—CHLORINE GAS.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
21	17.2 lbs. 125 fl. oz. Sul. Acid 500 " Water	1 hour	2 dishes	5	5	0	all	0	7	3	2 peaches with good sprouts, 3 dead.
22	8.6 lbs. 62.50 fl. oz. Sul. Acid 250 " Water	1 "	2 "	5	2 3 Jap. Plums	0	"	0	8	2	2 peaches making good growth. 2 plums making good growth. 3 apples looking poor, 2 dead.
24	17.2 lbs. 125 fl. oz. Sul. Acid 500 " Water	2 "	2 "	5	5	0	"	0		10	All died.
23	34.4 lbs. 250 fl. oz. Sul. Acid 1000 " Water	2 "	2 "	5	5	0	"	0		10	All died.
26	8.6 lbs. 170 fl. oz. Sul. Acid 670 " Water	2 "	2 "	5	5	0	"	0		10	All died.

Hydrocyanic Acid Gas.

Hydrocyanic acid is a colorless gas (HCN) and one of the most poisonous gases known. It has the odor and taste of prussic acid or bitter almonds. It is lighter than air, and is generated by adding water and sulphuric acid to potassium cyanide in about the following proportions:

Potassium cyanide	1 ounce
Sulphuric acid	2 fluid ounces
Water	4 " "

The quantities named have been determined by experiment to be suitable for one hundred cubic feet of space in fumigating dormant nursery trees. As potassium cyanide is often adulterated with sodium cyanide or with common salt (sodium chloride), only the best grade (98-99 per cent.) and the best commercial sulphuric acid should be used. The value of the tests with this gas is for purposes of comparison, and yet it also shows that nursery stock is not injured by it when properly fumigated. The results are given in Table V.

Results with Hydrocyanic Acid Gas.

All scales were destroyed and no trees were injured except in two lots one from each died, but there is no indication that they were killed by the gas. One point to be noted is that in Experiment No. 30 the trees were given the same quantity of cyanide commonly used for fumigating nursery stock (one ounce per 100 cubic feet) and twice the period. The trees were sprinkled thoroughly by means of a watering pot,—but none were injured by this fumigation. It should also be noted that twice the usual quantity for four times the usual period, and that three times the usual quantity for one-half hour (the usual period) caused no injury to the trees.

General Remarks.

These tests are preliminary and conclusions based upon them are scarcely warranted. Yet they indicate the desirability of making further tests with smaller quantities of carbon tetrachloride and with longer fumigating periods with the small amounts of carbon disulphide. Possibly it will appear that one or both of these liquids are suited for fumigating small lots

TABLE V.—HYDROCYANIC ACID GAS.

Expt. No.	Quantity of Materials for 100 cubic feet.	Fumigating Period.	Number of Generating dishes.	Number of trees.		Effect on Scales.			Effect on trees.		Remarks.
				Apple.	Peach.	Alive.	Dead.	Per cent. Alive.	Alive.	Dead.	
32	1 oz. Cyanide	½ hour	2 dishes	5	5	0	all	0	9	1	4 peaches made good growth, 1 started below bud. 4 apples made good growth, 1 died after starting.
30	1 oz. " *	1 "	2 "	5	5	0	"	0	10		All trees made fair growth.
25	1 oz. "	2	2 "	0	10	0	"	0	9	1	8 made good growth, 1 started below bud, 1 dead.
34	2 oz.	2 "	2 "	5	5	0	"	0	10		All trees made good growth.
36	2 oz. "	½ "	2	5	5	0	"	0	10		" " "
27	3 oz. "	½ "	2 "	0	10	0	"	0	10		8 made good growth, 2 made but little growth.

* Trees wet when fumigated.

of nursery stock, but at present we cannot do better than to use hydrocyanic acid gas in the same way as has been recommended. Care should be taken to do it properly, and the growth should be well ripened if treated in the fall.

It should also be noted that in many instances the apple trees were fully as susceptible to injury from the gases as peach trees. This is contrary to the belief of most nurserymen.

SPRAYING TESTS WITH COMMERCIAL "SOLUBLE OILS" TO KILL THE SAN JOSÉ SCALE.

By W. E. Britton and B. H. Walden.

Spraying tests with "soluble" or miscible oils were made on a few trees in 1907. On account of gypsy moth work, which required a large part of the funds at our disposal as well as nearly all of our time, it was impossible to devote much attention to spraying experiments. However, over two hundred young apple trees were treated with the three best-known commercial "soluble" oils on the market,—"Scalecide," "Target Brand Scale Destroyer," and "Kill-o-Scale." These substances are similar in composition and method of application except that Kill-o-Scale contains an addition of sulphur, while the others do not.

All the trees sprayed were apple trees except two Japan plums, and were portions of the orchards of A. E. Plant of Branford and E. M. Ives of Meriden. As the spring of 1907 was very late, the buds did not open until about the first of May. At Branford the spray was applied April 30th, and at Meriden, May 1st.

The tests show that all three products were about equally effective when used in the proportions of one part to fifteen parts of water. Very few scales survived the treatment in any case. The following tables give the statistics regarding these trials:

In addition to the tests recorded in the tables, all of the fruit trees on the station grounds were sprayed with "Scalecide," one part to fifteen parts of water, in the fall of 1906. When examined on March 29th very few living scales could be found. Mr. Ives also sprayed nearly all of his orchard of several

TABLE VI.—EXPERIMENTS AT BRANFORD, APRIL 30, 1907.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs—			Percentage efficiency of treatment.
				Winter killed.	Killed by treatment.	Alive after treatment.	
Apple	33	Moderately infested.	1 gal. Target Brand Scale Destroyer. 15 galls. water.	51.9	43.8	4.3	95.7
Apple	18	Moderately infested.	1 gal. Kill-o-scale. 15 galls. water.	60.	39.99	.01	99.99
Apple	57	Moderately infested.	1 gal. Scalecide. 15 galls. water.	56.	43.8	.2	99.8
	108						

TABLE VII.—EXPERIMENTS AT MERIDEN, MAY 1, 1907.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs—			Percentage efficiency of treatment.
				Killed by winter and by fall spraying.	Killed by treatment.	Alive after treatment.	
Apple	30	Badly infested. Sprayed in fall.	1 gal. Target Brand Scale Destroyer. 15 galls. water.	91.3	8.7	0.	100.
Apple	22	Badly infested. Sprayed in fall.	1 gal. Kill-o-scale. 15 galls. water.	97.7	2.29	.01	99.99
Japan Plum	2	Badly infested. Sprayed in fall.	1 gal. Kill-o-scale. 15 galls. water.	93.7	4.8	1.5	98.5
Apple	60	Badly infested. Sprayed in fall.	1 gal. Scalecide. 15 galls. water.	88.4	11.6	0.	100.
	114						

hundred trees with "Scalecide." The results were satisfactory. At Mr. Plant's orchard about seven hundred trees besides those recorded in the tables were sprayed with "Scalecide" by the owners, and the scale was kept well in check by the treatment.

A few words of caution should here be given for the benefit of those who use the "soluble oils." The contents of the original package should always be shaken or stirred so as to become thoroughly uniform before any is mixed with water. Directions to this effect are sent out by the manufacturers, and in some cases accompany each package. These directions should be followed. If such precautions are taken there will probably be no injury to trees from the use of "soluble" oils. If not thoroughly mixed, however, there is a slight separation of the ingredients, and the oil from the top of the barrel or can will not mix well with water and may cause injury to the tree. A large tree sprayed with one of these preparations not properly stirred was injured by having all the leaf and blossom buds killed on certain branches, which did not put out leaves until the other branches were in full leaf. Adventitious buds appeared, and later the tree was uniform in foliage. Sometimes after long standing it is necessary to add a small quantity of water and incorporate it with the oil before it will mix properly with the larger amount of water used at the time of applying it to the trees.

THE PEACH SAWFLY.

Pamphilius persicum MacGillivray.

A NEW ENEMY OF THE PEACH ORCHARD.

By B. H. Walden.

The peach orchard of Barnes Brothers at Yalesville, Conn., was visited at the request of the owners on June 14, 1906, to look at some insects that were flying around among the trees. Many trees in this section had been partially defoliated the previous season, and while the insects were not observed by the owners at that time, the occurrence of an unfamiliar insect in numbers in the same locality the following season at once suggested the cause. The insect proved to be a four-winged fly about three-eighths of an inch long, the head and thorax black with yellow markings, the legs and abdomen reddish brown or brown ocher in color. At this time only six or eight were seen flying around each tree in the infested locality, but Mr. Barnes informed me that they had been very numerous a few days earlier. Upon examining the trees, numerous white eggs were found on the under side of the peach leaves, and some of these eggs were beginning to hatch. The number of eggs observed at once suggested that the insect might prove to be quite a pest.

Material was collected to rear, but while the writer was absent from the station in connection with other work, all specimens died. The next visit was made to the orchard July 27th, when all the larvae had disappeared. A number of trees had been badly defoliated, and evidences of the work of the insect were seen over a considerable area in the orchard. Observations made on this insect during the past season are presented in the following pages.

IDENTITY OF THE PEST.

This insect promised to be interesting even before we saw it, as there are comparatively few insects that feed upon peach foliage. The specimens were sawflies, hymenopterous insects, belonging to the family *Tenthredinidae* (a familiar example of which is the common currant worm). They are called sawflies because the ovipositor of the female consists of a pair of plates with serrated edges, with which some of the species "saw" into the tissues of plants, where they deposit their eggs. Specimens were sent to Dr. A. D. MacGillivray of Cornell University, a specialist in this group, who pronounced it a new species and described the insect as *Pamphilius persicum*.*

Another sawfly, *Selandria obsoletum* Nort., has been reported by Prof. H. A. Morgan,† as seriously defoliating peach and plum trees in Louisiana, in an article giving a description of the insect and its work.

INJURY TO TREES.

The peach sawfly feeds upon the foliage and the injury depends of course upon the extent to which a tree is defoliated. In 1906 many trees in one section of the orchard were quite badly defoliated (see Plate VI, b.), and while surrounding trees showed some damage it was not noticed in another neighboring orchard, thus indicating that the insect was quite local in its work. This year it was more widely distributed, being found in all of Barnes Brothers' orchards, and appeared less local in its movements, though this feature could not be definitely observed, as the badly infested locality of the previous season was all thoroughly sprayed this year. In the orchards of Messrs. Hopson, Hall and Lyman the work of the insect was observed over considerable areas, but was nowhere serious.

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* Canadian Entomologist, Vol. XXXIX, p. 308, 1907.
† La. Expt. Station Bull. 48 Second Series, p. 142, 1897.

The work of the insect is very characteristic, and is first noticed by the rolling of the leaves and later by their shredded appearance as shown on Plate I. This is more fully described under habits of the insect.

Food Plants.

This sawfly seems to be confined almost entirely to the peach. The foliage of the native trees and plants in the vicinity of the peach orchards, especially those belonging to the rose family, was carefully examined. The only plant found on which eggs had been laid and larvae were feeding was a small bush of the wild black cherry, *Prunus serotina* Ehrh. This was in an old division wall between two portions of the orchards in the badly infested locality. Other black cherries in the vicinity of the orchards were examined but no eggs or larvae were found on them. Many adults were seen resting on the leaves of apple trees, a number of which were in the peach orchard, but no eggs were found on them. On Japanese plums and sour cherries near the infested orchards no trace of the insect was found. In one of the breeding cages, where there was no chance to oviposit on peach foliage, a few eggs were laid on common sorrel, *Rumex acetosella* Linn.

These observations are contrary to the usual habits of native insects that become serious pests. Ordinarily the species will be found feeding on a number of closely allied wild plants, and gradually begins to work on cultivated species, the injury increasing from year to year. A new pest suddenly breaking out in numbers and confining its work to a single cultivated plant, as the peach sawfly is apparently doing, strongly suggests its being an introduced species. In regard to the peach sawfly it is certainly hard to answer the question,—where did they all come from?

ABUNDANCE.

From the examination made in the summer of 1906 it was evident that the insect must have been very numerous over quite a section in part of the orchard. They were the most abundant in this section during 1907. A few notes were made regarding the number of larvae and adults, as follows:

On May 15th a shovelful of earth examined contained *forty-six* larvae. The hole at the greatest diameter measured ten by eleven inches, and five and one-half inches deep at the deepest point. It was two feet ten inches from the nearest tree. This was the first shovelful examined, taken up at random at least two hundred feet from where the insect was found to be the thickest the previous year. The photograph of the holes where adults had emerged (Plate IV), was taken in the same vicinity, the particular spot not being selected on account of the large number of holes, but because it was level and free from rubbish, and is a fair record of conditions on between two and three acres. This photograph was taken natural size on a 5 x 7 plate, looking directly down on the ground, and shows thirty-seven exit holes, or a fraction over one to the square inch. In one of the small breeding cages, containing exactly three square feet, which had received no treatment, 132 adults emerged or 44 to the square foot. A few wings and parts of sawflies were found which may have been eaten by carabid beetles, and these would have increased the total number.

The greatest number of adults were seen on a visit to the orchard June 12th. They were especially abundant in an opening where a number of peach trees had been cut out; here they collected in swarms on the grass and weeds. They were so numerous as to make a slight rustling sound.

Needing adult specimens for our collection, etc., 462 specimens were taken, with an ordinary twelve-inch net, by sweeping it over the grass and weeds for about ten seconds. Twelve eggs were the largest number noted on a single leaf.

NATURAL ENEMIES.

Considerable time was spent looking for parasites, especially of the egg and larva, but no hymenopterous parasite or fungous disease was observed attacking either. Numerous carabid beetles belonging to the genus *Harpalus* were present in the section where the sawflies were especially abundant. Many fragments of the adults, which had evidently been eaten, were found in the breeding cages and while these beetles were not observed feeding on the sawflies, their presence indicated that such may have been the case. Numbers of small toads in the orchards may have also helped to reduce the numbers.

LIFE HISTORY.

The spring of 1907 was cold and backward, and the dates here given are considerably later than they would be in a normal season. This is shown in one or two cases where the date for the previous season is given. The various stages probably overlapped each other much more than they would in a normal season. Mr. Barnes remarked that he thought the adults were seen for a longer period and the larvae were feeding longer than they were the year before.

The adult sawfly emerges from the ground the last of May or first of June. The first adults were observed June 4th and the last date that any were seen was June 27th. They were the most abundant on June 12th, while in 1906 the majority had disappeared by June 14th. The eggs were first found on June 12th, eight days after the first adults were observed. These were found only after considerable searching, and then but five, one leaf with two and three with one each; the majority of the eggs were laid after June 14th. The eggs hatch in six to eight days, the first larvae being observed June 20th. In 1906 many eggs had hatched by June 14th. The larvae become grown in eight to ten days, considerable injury having been done to trees not sprayed by the end of June. The larvae go into the ground and remain until the following spring. The larvae transformed rather irregularly, pupae being found from May 21st until after the middle of June. A few larvae were found June 20th, and while no further notes were made, it is quite probable that at least some of these remain in the larval stage until the following spring. Adults began to appear fourteen days after the first pupae were observed. There is but one brood in a season.

HABITS.

After emerging, the adults collect together in groups or swarm in sunny places. At the time the adults were the most numerous (June 12th) but few were seen on the trees, but in places where trees had been cut out they were very numerous, flying around and running over the grass and weeds. While the sun was shining they were very active, but when a cloud passed over the sun they would settle down and become quiet. The next visit to the orchard was on June 14th, which was a cloudy, windy day, and the insects were very quiet, even sluggish. On the previous date many of the insects were mating but the females were not observed in the act of ovipositing. The small whitish eggs are laid horizontally on the surface of the under side of the leaf along the midrib and on the basal portion of the leaf. See Plate II, a. The larva after hatching crawls to the edge of the leaf and soon spins a web of a few whitish silken threads over itself. When it begins to feed it eats a narrow strip inward from the edge and by means of the web draws or rolls the corner of the portion on which it rests over itself, forming a case within which it stays during the day, coming out to feed towards dark. Much of the damage is done when the larvae are nearly full-grown. Leaves partly eaten and with the characteristic rolling are shown on Plate I. The midrib of the leaf is left, and to it is often attached more or less of the adjoining tissue, thus giving to the foliage on the infested trees a peculiar shredded appearance. Small trees, set to replace large trees that had been removed, were often found nearly stripped while the surrounding large trees might show but little of the work. This may be due to their preference for sunny places.

After the larvae become full-grown, they go into the ground, where they remain until the following year. Observations regarding these larvae were made in April and May. From considerable digging and many measurements the majority of the larvae were found to be about three inches deep, though some were within two inches of the surface, and the deepest were between five and six inches. The only larvae found less than two inches deep were three that were obstructed by a large flat stone. Larvae occurred within six inches of the tree trunk and halfway to the adjoining tree, or in other words, they could be found in the soil all the way from one tree to another, but were the thickest about thirty inches from the base of the tree. The larva forms a small round unlined cell about one-fourth of an inch in diameter within which it remains curled up. The color of the larvae had changed from pale bluish green to a bright apple green. Larvae examined early in November had assumed this color.

When the larva pupates, no cell is formed, the larval skin is discarded and usually remains attached to the last abdominal segment, and the pupa is free. It has the same general shape as the adult; the antennae, legs and other appendages simply with a thin covering. Pupae are shown on Plate III, c.

EXPERIMENTS IN CHECKING THE INSECT.

At the time the experiments were started it was not definitely known that peach foliage could be sprayed in Connecticut with arsenate of lead, or in fact with any spray mixture. It was well-known that Bordeaux mixture was injurious to the foliage, and statements had been made to the effect that arsenate of lead was injurious. Three methods of combating this pest were tried, (1) cultivating the soil thoroughly while the insect was in the pupal stage; (2) treating the soil with carbon disulphide during the same period; (3) poisoning the larvae soon after they hatch by spraying the foliage with internal poisons.

Cultivating the Soil.

We have found in rearing sawflies that certain species are easily killed by disturbing the soil after they have gone into it to pupate. This suggested cultivating the soil thoroughly, especially near the trees, while the peach sawfly was in the pupal stage, as a means of reducing its numbers.

In order to note definitely the results, tight wire-covered cages were made and placed around a number of trees to retain any adults that might emerge within the area. These cages consisted of frames six feet square made of boards seven or eight inches wide and covered with wire mosquito netting. Each cage was built around a tree, the tree being in the center, with the netting fastened to the tops of the frames and fitted tightly around the tree. The cages were hinged at the middle so that one side could be raised and the soil cultivated halfway around the tree. This side could then be lowered and the opposite side raised and the soil cultivated on that side. The sides were then banked with earth to make the cage tight. A view of these cages is shown on Plate V, a., and a nearer view of a cage with one side raised is shown on Plate V, b.

Two cages were left as checks, and in four the soil was cultivated, once, twice, three and four times respectively. The ground was stirred as thoroughly as possible with a spade to a depth of at least four inches. All lumps were crushed, making the cultivation probably more thorough than would be possible with any of the ordinary orchard tools. The dates, number of times cultivated, etc., are given in the following table:

Cage No.	1st cultivation	2d cultivation	3d cultivation	4th cultivation	Condition June 12 (No. adults)	Condition June 14
2	May 23	------	------	------	About 12	Many adults
3 (check)	------	------	------	------	About 12	Rather more than in cultivated cages
7	------	May 28	June 4	------	6–8	Many adults
4	------	May 28	June 4	June 7	3	Many adults
5	May 24	May 28	June 4	June 7	12 or more	Many adults
8 (check)	------	------	------	------	About 50 adults *	Rather more than in cultivated cages

The cultivation seemed to slightly delay the development of the insect and on June 14th more adults had emerged in the check or untreated cages than in the cultivated; but at the next visit there was very little difference. Slight difference was noted between the cages cultivated a different number of times, and even in the cage where the soil was cultivated four times, which would not be practicable in orchard work, the treatment did little more than to retard the development of the insects.

During the latter part of May the orchard was plowed with a light gang plow, turning three furrows from two and one-half to three inches deep; this turned up many larvae, but there were still many left below the bottom of the furrow, and the majority of those that were plowed up emerged, as was shown by the numerous exit holes.

Carbon Disulphide.

Carbon disulphide has long been used in France against the grape phylloxera. The substance is injected into the soil around the vines, and the liquid evaporates, though much more slowly than it does in the air, and spreads through the soil. It is used in this country in various ways for underground insects, especially in killing ants. Professor Slingerland of Cornell University has used it successfully in experiments against the cabbage maggot.*

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* No. 8 was on rather higher ground than the other check, No. 3. No. 7 was a tree in row opposite No. 8.

In our tests two cages were used like those described for the cultivation experiments. These cages were placed in the rows with the others, and the same check cages served for both experiments.

In one cage the carbon disulphide was used at the rate of one fluid ounce to a square yard, and in the other twice that amount, two ounces to a square yard. Holes five or six inches deep were made about eighteen inches apart, or four to the square yard, and an ounce of the liquid was divided between the four holes, or about two teaspoonfuls put in each hole, after which the opening was quickly closed with the foot.

The ground in the second cage was treated in the same manner excepting that double the quantity was used. This treatment proved effective, as no adults emerged in either cage. The insects might have been killed with a smaller amount of carbon disulphide, although the actual amount required would depend upon the mechanical condition of the soil. A light, dry, porous soil will require more than a heavy, compact, moist soil, as in the former the carbon disulphide is evaporated much more rapidly and the fumes would not be retained long enough to kill the insects unless a large quantity was used. The greatest drawback, however, is that there is no tool on the market with which the carbon disulphide can be injected into the soil. An instrument was devised by Mr. McGowen, inventor of the McGowen spray nozzle, called the McGowen Injector, and was suited for just such work as is mentioned above. The injector was put on the market, but owing to the small demand for such an instrument, its manufacture was discontinued.

Treating an orchard with carbon disulphide, even with a suitable injector, would of course be very expensive, but the experiment was made before we were sure that spraying could be practiced, and had the latter proved impracticable, this would have been the only treatment we could recommend.

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* Cornell Expt. Station Bull. 78, p. 531, 1894.

In the above cultivation experiments and in those with carbon disulphide duplicate tests were made with small cages containing three square feet. These tests gave similar results to those of the large cages.

Spraying with Poisons.

At the beginning of the season we were in doubt as to whether the peach foliage could be sprayed with any poison. Dr. J. B. Smith, State Entomologist of New Jersey, informed us that he had used arsenate of lead on peach foliage without apparent injury. A statement was made by Prof. A. L. Quaintance of the Bureau of Entomology that in some experiments with arsenical poisons on peach foliage, all materials used injured either the foliage or the fruit.* As soon as the leaves were out sufficiently to make a test, fourteen small peach trees on the station grounds were thoroughly sprayed with arsenate of lead at the rate of one ounce in one gallon of water, which is about equal to three pounds in fifty gallons. No injury followed. This test was repeated with another brand of arsenate of lead with the same results.

The following materials were applied in Barnes Brothers' orchard to note the effect on the trees and insects:

Vreeland's arsenate of lead 3 lbs. in 50 gal. water	5 trees
" " " " 1½ lbs. in 50 gal. water	5 trees
Paris green ½ lb., 3 lbs. lime in 50 gal. water	10 trees
Hellebore, 3 lbs. in 50 gal. water	6 trees

These trees were sprayed on the forenoon of July 6th, and the application was followed by a light shower that evening. A visit was made to the orchard July 9th, and it was found that through a mistake these trees had all been resprayed that morning with arsenate of lead, which was being used on the remainder of the orchard. These trees were examined several times, and no injury was noted even where the Paris green was applied.

Extensive Spraying Operation by the Owners.

Probably the most extensive spraying operation ever undertaken in the Eastern States in a peach orchard when in foliage was carried out by the Barnes Brothers during this last season. Several hundred pounds of arsenate of lead was applied to

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* Bureau of Entomology Bull. No. 67, p. 47, 1907.

4,000-5,000 trees between June 24th and July 10th. The owners intended to spray more, but during the first week in July had to suspend operations to wait for a shipment of lead arsenate. The arsenate of lead purchased was manufactured by the Powers-Weightman-Rosengarten Company of Philadelphia,* and was applied at the rate of 2½ to 3 lbs. in fifty gallons of water.

The larvae, like many sawfly larvae, were very readily killed by the poison, and probably used at one-half this strength (one and one-half pounds in fifty gallons) would have been effective. Mr. Barnes was unable to be in the orchards much of the time to see that the men thoroughly covered the foliage, and the stronger solution was used partly for this reason. Plate VI, a., shows the sprayers at work in this orchard.

Owing to the peculiar season, the young larvae probably appeared more irregularly than they would in an average season. During the first ten days of July many trees showed considerable of the insect work, and many of the larvae became full-grown, but there were still many partly grown larvae present on the same trees which might add much to the damage already done, and the spraying was continued until the 9th of July. The treatment was entirely successful, the work of the insect being checked wherever the trees were sprayed. From my notes of July 3d regarding trees sprayed about the 24th of June:—"Found many dead larvae in the rolled leaves on the sprayed trees, and the foliage shows a marked difference from that on trees not sprayed."

The writer examined many of the sprayed trees for two or three weeks following the operation, and in no case was any injury to the foliage seen. Mr. Barnes watched throughout the season, a number of trees which had received an extra heavy coating of arsenate of lead, and though the mixture showed on the foliage until the leaves fell, no injury was observed.

DESCRIPTION.

Egg. The eggs are pearly white in color, 1.64 mm. (average of six) in length, and .6 mm. (average of four) wide, sides nearly straight and of uniform width, the ends regularly and broadly rounded. Occasionally an egg is very slightly curved.

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* Analysis, Conn. Agric. Exper. Stat. Bull. 157, p. 5, 1907. (See page 323 of this report.)

They are laid longitudinally along the midrib of the leaf. See Plate II, a.

Larva. When first hatched is pearly white in color with brown eye-spots on either side of the head. Mouth parts and antennae tipped with brown. Antennae .16 mm. long. Length about 2.5 mm. Head about .5 mm. wide, exceeding the body, which is .45 mm. wide back of head. Body fairly uniform in width, tapering somewhat towards anal end. Abdominal segments slightly wrinkled. Anal segments with a pair of three jointed appendages about .12 mm. long, the basal joint large, the second smaller and shorter, the third tapering to a point.

Full-Grown Larva. Length 15 mm., width 2.25 mm. Color pale bluish green, including the head; mouth parts, antennae, and anal appendages brownish. First thoracic segment with a dorsal transverse mark between two sublateral spots. Head roundish, about 1.5 mm. wide. Antennae slender, seven-jointed. Abdomen without prolegs, the segments wrinkled transversely, four wrinkles to a segment; the last abdominal segment flattened, tipped with a row of slender hairs and with a pair of three jointed appendages situated laterally on the ventral side. The larvae are shown on Plate II, b. and c.

After entering the ground the color of the larva changes to a bright apple green.

Pupa. No cell or pupa case is formed. The pupa is naked with all the appendages free, simply covered with a thin membrane. The head and thorax apple green, abdomen and appendages yellowish green. Before emerging the color and markings of the adult insect are plainly visible. Shown on Plate III, c.

Adult.

Dr. MacGillivray has described the female as follows:

"*Female*—Body black, with the following parts yellow: the labrum and clypeus broadly, the posterior orbits, the front orbits with a band extending to the occiput, with two tooth-like projections on the mesal side near the eye, a pair of lunate marks behind the ocelli, a small spot on the hypoclypeal area, the palpi, the V-spot, the tegulae and base of the wings, the scutellum, the post-scutellum, a small irregular spot on the pleura, and the legs, except the extreme bases of the coxae, becoming rufous beyond the middle of the tibiae; mandibles and abdomen rufous; antennae with thirty segments, the third and fourth subequal in length. Length, 10 mm."*

Male. Color and markings similar to female except the following:—The front orbits with a large irregular yellow spot opposite the eye, the lower edge continuous with the yellow of the posterior orbits. The yellow band extending from the inner superior border of the eye to the occiput. Antennal pits and the under side of the first basal antennal joints yellow. The lunate marks behind the ocellus smaller. Abdomen with the sides blackish and at least the posterior dorsal margins of the segments blackish, in a few specimens almost the entire dorsal surface of abdomen blackish. The ventral side rufous except at the lateral edges. Anal appendages rufous. Average length 9 mm.

Both sexes and their characteristic facial marking are shown on Plate III, a. and b.

DISTRIBUTION.

Our attention was called to this insect in 1906, and Barnes Brothers observed its work in 1905. Since then we have received no complaint from other orchardists of injury that could specifically be laid to this pest. Observations regarding the distribution of the peach sawfly have been made as follows, the larger orchards having been visited especially to look for the insect or its work:

PLACES WHERE THE INSECT HAS BEEN FOUND.

New Haven, June, in three city gardens and in garden of Experiment Station.

Meriden, July 9th, small peach orchard of E. M. Ives; occasional leaves had been eaten, and a few full-grown larvae were found.

Centerville, July 12th, orchard of George C. Neal. A number of larvae. The pest evidently well established.

North Haven, July 12th. The insect was present upon a few peach trees in a henyard.

East Wallingford, July 17th, orchard of George A. Hopson.

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* Canadian Entomologist, Vol. XXXIX, p. 308, 1907.

Found considerable work of the insect, a few small trees with leaves nearly all stripped.

Orchard of Linus Hall, the insect rather more prevalent than in the orchard above mentioned.

Middlefield, July 17th, orchard of Charles E. Lyman. Conditions about the same as in East Wallingford.

Farmington, August 7th, orchard of Root Brothers. A few leaves eaten by this insect on two or three trees.

Young orchard of Prof. H. W. Hillyer showed evidences of the insect.

Mr. J. Norris Barnes reported the insect in their orchards at Cheshire and also at Durham.

ORCHARDS EXAMINED WITH NO INDICATION OF THE SAWFLY.

West Haven, July 5th, orchard of N. S. Platt.

Westport, July 16th, orchard of S. B. Wakeman.

Seymour, August 13th, orchards of Hale & Coleman.

Rocky Hill, August 15th, orchards of W. F. Griswold.

South Glastonbury, August 15, orchard of J. H. Hale.

Hartford, September 12th, peach trees in four city gardens.

New Canaan, Sept. 18th, orchard near Stephen Hoyt's Sons' Nursery.

Norwalk, October 3d, small orchard of Comstock & Lyon.

As far as we know, this insect has not been observed outside of Connecticut. A note was published in Bulletin 67 of the Bureau of Entomology, p. 87, stating that it had been observed in New Jersey and also in Pennsylvania, but these records refer to the distribution of an entirely different sawfly, *Priophorus acericaulis* MacGillivray, which confines its work to maple trees.

WILL THE PEACH SAWFLY BECOME A SERIOUS PEST?

Since the peach sawfly has been brought to the attention of the fruit growers, there have been many questions regarding its importance as a pest. It is hard for the orchardists to become reconciled to the fact that they have got to spray their orchards every one or two years for the San José scale, and the possibility of having to give their orchards an additional spraying for this pest is indeed discouraging.

It is impossible to predict with any certainty regarding this new pest. The sawfly promises to become distributed throughout the state, as it has been found in New Haven and Middlesex counties at points nearly thirty miles apart; but whether it will become numerous enough to cause serious injury depends largely upon the rapidity with which it multiplies, and the part that natural enemies may take in reducing its number. From our observations, the numbers are not greatly increased during a single season, and it would seem that the pest would necessarily have to be present in an orchard several seasons before it would do extensive damage. The larvae are very easily killed by arsenical poisons, and it is quite possible that one application may reduce their numbers sufficiently so that the operation would not have to be repeated for two or three years. It will be necessary to study the insect for a number of seasons before we can judge regarding the seriousness of the new pest that has been found in our state.

ACKNOWLEDGMENTS.

The writer is indebted to Dr. Britton, under whose direction the work has been done, for much help and many suggestions.

To Barnes Brothers, who placed their orchard at our disposal, furnished lumber for breeding cages, and assisted the work in many ways.

To Mr. George A. Hopson and Mr. Charles E. Lyman, who spent considerable time at a very busy season, conducting the writer through their orchards.

RECOMMENDATIONS.

From our experience we recommend spraying the foliage with arsenate of lead, using it at the rate of one and one-half to three pounds in forty to fifty gallons of water. This should be applied as soon as the larvae begin to hatch, or if a large area is to be sprayed with a limited amount of help, the work could probably be started shortly after the eggs are laid. The exact date will depend, of course, upon the season; this was found to vary about two weeks during the past two seasons. The point is, the larval stage is short and the work must be done quickly at the proper time, and in order to determine this a close watch must be kept of the progress of the development of the insect.

Carbon bisulphide will kill the insect in the larval and pupal stages, but is probably too expensive to warrant its use; besides there is no injector with which to apply it, on the market at the present time.

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MacGillivray, A. D. Canadian Entomologist, Vol. XXXIX, p. 308. (Original description of female.)
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PROGRESS OF THE WORK OF CONTROLLING THE GYPSY MOTH IN CONNECTICUT.

The first account of the discovery of the gypsy moth in Connecticut in March, 1906, was published in Bulletin 153 of this station. The report for 1905 was then being prepared, and in it was included, on page 246, a more complete history of the discovery. Work was started immediately and kept up until September 1st. The details were published in full in the report for 1906, page 235. The present paper is a report of progress during the calendar year of 1907.

Beginning November 16th, 1906, Mr. George H. Hollister has had immediate supervision of the work, and to his faithfulness and ability much of its success is due. During the winter three men worked with Mr. Hollister, scouting for egg-masses, pruning trees and cutting brush. After the caterpillar season began, the force was increased, twenty being the greatest number of men employed at any one time during the banding season. Excellent progress has been made in the suppression work, as a large number of trees were banded, brush cut and trees pruned over a large area, and the total number of caterpillars found was less than one-third the number taken during 1906.

On September 1st the work was suspended on account of the annual inspection of nurseries, and again resumed on November

18th. Details of the suppression work are given in the following pages.

SCOUTING AND DESTROYING EGG-MASSES.

All trees throughout the infested region, including those in the village and as far north as the cemetery road, were examined by the men during the winter. In the immediate vicinity of known infestations, fences, walls and buildings were also carefully inspected. Plate VII shows men engaged in scouting and destroying egg-masses. Creosote is applied by means of a brush, enough being used to thoroughly soak the egg-mass, and this prevents the eggs from hatching. Much of this territory was again examined in December. About 106 unhatched egg-masses laid in 1906 were found and destroyed by the men employed by the state. Considerable time in summer was spent scouting for caterpillars.

GOVERNMENT COÖPERATION IN SCOUTING.

Following previous arrangement by correspondence, Mr. D. M. Rogers, special field agent in charge of the Government work against the gypsy and brown-tail moths, put four men at work scouting about Stonington on March 20th, and later their force was increased to five. These men were instructed to make a careful search over the whole town of Stonington and the easterly portion of Groton near West Mystic, eastward surrounding Westerly, R. I., and north to include a portion of the town of North Stonington. The Government men examined not only the infested region, which was later scouted by state men, but a large area surrounding this region. No egg-masses were found outside the limits previously known to be infested. Twelve egg-masses were found by the Government scouts, who were engaged about four weeks in examining this territory.

DESTROYING EGG-MASSES IN STONE WALLS.

In several of the worst infested spots caterpillars transformed in stone walls, and the females there laid their eggs. In order to destroy them it was necessary to overhaul the stones and treat each egg-mass with creosote. Around the places of M. Chesebro, F. Allen, and near the Alexander Rose estate on North Main street sections of stone wall were overhauled and relaid, altogether about fifteen rods being thus treated.

EXAMINING WOODPILES.

Piles of wood, lumber and rubbish near which caterpillars were found were suspected of containing egg-masses and were therefore overhauled and examined. One pile of old railroad ties at F. Allen's (shown on Plate X, a.) contained seven egg-masses. The pile of waste lumber, packing boxes, etc., at the velvet mill was also looked over, and six egg-masses found. Ten such piles of rubbish, lumber and fuel were examined.

PRUNING AND SCRAPING ORCHARD TREES.

There are many old apple trees in and about the infested region at Stonington. Some of these are in orchards and were planted, but others, probably chance seedlings, are scattered over the fields or are growing beside the stone walls. A large proportion of them have been neglected for many years, and the tops were filled with a tangle of living and dead branches, and the trunks and larger limbs covered with lichens and loose rough bark. As the gypsy caterpillars are found on such trees, it was absolutely necessary to put the trees in such shape that effective work could be done in controlling the insect. During January a heavy fall of snow made brush cutting impracticable, and the men went to work pruning and scraping these old apple trees. The dead wood was first removed, then enough thinning was done in the tops to let in the light and air. In all about 450 such trees were pruned during the year, and over two hundred trees were scraped. The wounds were painted wherever large branches were cut. Views of the pruning operations are shown on Plate VIII.

Rough bark on the trunk and branches of a tree enables the caterpillars to find protection under the upturned edges of bark so that they will not crawl under the burlap bands. Likewise, if the top of a tree is thick and dark, the caterpillars there are sufficiently protected, and cannot be trapped under the bands.

FILLING AND TINNING CAVITIES.

Many of the trees described above contained cavities caused by the neglect of broken and decayed branches, and these cavities were convenient places for the caterpillars to hide out of reach of all enemies. In them caterpillars will transform, and later perhaps egg-masses will be laid therein and escape discovery. It was therefore necessary to fill these cavities so as to exclude the caterpillars. In some cases this can best be done by filling the opening with stones and cement, and in others it is better to nail a piece of tin over the opening, fitting it around the edges so that caterpillars cannot crawl under it. Wherever tin was used, the metal was painted over with dark paint to make it as inconspicuous as possible. In this manner cavities were filled and covered in 130 trees during the year.

Plate XII shows a tree that has been scraped and pruned and the cavities filled.

BANDING TREES WITH BURLAP.

Burlap bands were placed around the trunks or stems of trees as described in the report for last year, page 238, but the bands were applied to trees over a much larger area than was covered last year, nearly ten times as many bands being used. All trees were banded through the streets and back yards of the village and as far north as the cemetery road from the Wequetequock River west to Sheridan's Corner, on the Mystic road. All trees for a distance of about two hundred yards north of the cemetery road, including three apple orchards, were also banded, but no caterpillars were found there.

During July caterpillars were found on maple trees along the drive leading from the Mystic road to Walnut Grove. All trees in this vicinity were banded at once, about eight hundred being so treated.

Altogether about thirteen thousand trees were banded in 1907. The appearance of banded trees is shown on Plate XI and the method of applying the bands may be seen on Plate X, b. The first banding was done about May 25th. Burlap (eight ounce weight) was purchased from Boston, all cut into ten inch strips ready for use. In the infested area these bands were examined each day through the caterpillar season; outside this area they were turned every second day, and later twice a week.

DESTROYING THE CATERPILLARS.

The territory was divided into sections, and each man engaged in examining bands was given a section of banded trees. Notes were kept each day of all caterpillars found and of the locality where taken. Thus at the end of the season we had a record of the entire matter, and knew where to look for the greatest number of egg-masses. The caterpillars were gathered with forceps and destroyed in the same manner as last year, by dropping them into small bottles of alcohol carried by the men.

CUTTING BRUSH.

Plans were made to clear from brush all of the land between the northernmost extension of the water from Stonington harbor to the Wequetequock River and as far north as the cemetery road. Mr. Phelps, at his own expense, had cut considerable brush just east of his residence and south of the cemetery road, and by January 8th, 1907, a strip had been cleared from water to water, though not very wide, near the east entrance to the cemetery. During the first part of the winter there was little snow, and the brush cutting work could be carried along without hindrance. Some brush cut during August had not been burned, and this was gathered and fired. Considerable heavy brush east of the cemetery was cut in early summer, and the section between North Main street and Elm street south of the cemetery road was entirely cleared of brush except a small patch just east of Mr. Phelps' house, which was cut in November, 1907. The heavy brush near Mr. Atwood's was also cut and the remaining trees pruned, but it was not possible with the force employed to cut all of the scattering brush in the pasture north of Mr. Atwood's house. This area was finished up in December, 1907. As a few caterpillars were found at Walnut Grove in July, a gang of men were set at work cutting brush in this vicinity. Mr. Hollister estimates that during the past year a hundred acres of brush land has been cut over, and some of this was heavily covered with green brier (*Smilax rotundifolia*), often called "bull brier," making the work extremely difficult. Some of the men were so badly poisoned with poison ivy that for a few days they were unable to work. Brush along the boundary walls of fields and meadows has also been cleaned up over an area of about three-fourths of a square mile. Brush cutting work is shown on Plate IX.

INFESTATION AT WALNUT GROVE.

About the middle of July the men found some gypsy caterpillars on the trees beside the drive leading from the Mystic road to Walnut Grove. Men were at once put at work there, and a considerable area of brush cleaned up. Some eight hundred more trees were banded in the vicinity and though much hunting was done for caterpillars, only a few were found, and most of these were on trees between the house and the northernmost extremity of water. Though the trees have since been examined very carefully for egg-masses, none have been found. Not even an old one has been discovered. How the caterpillars reached this place is a matter of conjecture, but it is possible that an egg-mass or a portion of an egg-mass was blown across the water on the ice. On the other hand, it is possible that one or more egg-masses were laid at Walnut Grove in 1906 and escaped detection.

INFESTATION OF SPRUCE TREES AT THE STANTON PLACE.

During August, after the caterpillars had transformed, Mr. Hollister, on looking into the top of one of the Norway spruces, of which there are several on the Stanton place, noticed some female gypsy moths laying eggs. This tree was immediately given a thorough examination, and over fifty new egg-masses were found. These were creosoted, and later the tree was cut and burned. A similar number of egg-masses was found in the other spruce trees in December. Although these trees were all banded, few caterpillars were taken from under the bands, and there was no indication that the trees were infested to any such extent. The tops of the trees were thick and dark, and furnished to the caterpillars all the protection necessary, hence they did not descend to hide under the bands. The caterpillars had eaten some of the leaves in the tops of the trees, but not enough to be noticeable from the ground. The excrement even did not indicate their presence by dropping to the ground, but was caught and held by the thick leafy branches underneath. It was an extremely difficult matter to find and destroy the egg-masses on these trees, as some of them were at the extremities of the branches on the small twigs, and nearly all on the under side. In spite of the very thorough examination given these trees, some egg-masses may have been overlooked, and a close watch must be kept on them next season. No egg-masses were found on the arbor-vitae trees growing near by on the premises.

STATISTICS.

	1906	1907
Egg-masses laid during preceding year, number destroyed	29	118*
Egg-masses laid during same year, number destroyed	47	70
Caterpillars, number destroyed	10,000	2,936
Pupae, number destroyed	47	200
Trees banded with burlap, number of	1,300	13,000
Funds expended by the state†	$1,500.00	$4,550.00
" " " " government	——	272.00

TRANSFORMATIONS OF GYPSY MOTH IN CONNECTICUT IN 1907.

The spring was an unusually late one, all forms of vegetation being fully two weeks later than usual. Ordinarily the eggs hatch soon after May 1st, but a cluster placed in the breeding cage did not hatch until May 18th, when 382 caterpillars had emerged from it, and the first caterpillar taken from the trees was found on June 8th. The first pupa of the season was found on July 25th, and only a few had been taken August 1st. The pupa stage lasts from ten to fourteen days, when the adults emerge. They soon mate and the females lay eggs, which hatch the following May. Thus about nine months or three-fourths of the year are passed by this insect in the egg stage. Caterpillars, adults and egg-masses are shown on Plate XIII.

MEN EMPLOYED IN THE WORK.

Throughout the year Mr. G. H. Hollister has acted as local superintendent and has been given full authority to employ or discharge men as he saw fit. All other men employed have been residents of Stonington or vicinity. Laborers were paid $1.50 per day of nine hours for the time which they worked, but during the summer, when most needed, they were given $9.00 per week as a guarantee against loss of wages on account of bad weather, and reported each morning, even though stormy, as some of the men could be used in sharpening and repairing tools. Through the winter months Mr. Hollister and three men worked scouting, cutting brush, pruning and scraping trees, but the force was increased as needed, until during the caterpillar season twenty men were employed.

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* Including twelve found and destroyed by government scouts.

† These amounts are for the calendar and not for the fiscal year.

All work was suspended September 1st, and Mr. Hollister assisted in inspecting the nurseries of the state. On November 18th work was resumed at Stonington by Mr. Hollister and six men.

FUNDS.

The report for 1906 explained (page 245) how a portion of the general fund received by the station from the state was used in controlling the gypsy moth and also how eight hundred dollars was appropriated for the purpose by the State Board of Agriculture. During 1907 the expenses were met from the insect pest fund prior to the passage of a bill by the legislature providing for the prosecution of the control work. As this bill did not finally become a law until June 5th, and as none of the money could be used to pay bills contracted before that date, we came very near being obliged to stop work at a critical time for lack of funds. In order to keep the men at work the State Board of Agriculture appropriated one hundred dollars on May 25th. The new state appropriation of one thousand dollars became available on June 5th, and was immediately drawn, and as soon as the legislature adjourned the State Board of Control appropriated fifteen hundred dollars more, which amount was nearly all expended when the work was temporarily stopped on September 1st.

After the leaves had fallen so that scouting for egg-masses could be done advantageously, the Board of Control granted another one thousand dollars, which had been only about half expended on January 1st, 1908. Thus during the calendar year approximately $4,550 had been used, and this, together with the amount expended in 1906, make a total of more than six thousand dollars thus far expended in attempting to exterminate the gypsy moth colony at Stonington.

LEGISLATION.

Prior to June 5th, 1907, no special legislation regarding the gypsy or brown-tail moths had been enacted in Connecticut, and in the control work at Stonington the state entomologist had no authority except that granted under the insect pest law—Sections 4386-4390 of the Revised Statutes. Consequently it was necessary to obtain the owners' permission before cutting brush, pruning trees, etc., though clearly we had the right to enter any premises in the performance of our duties. More authority, as well as funds, was needed, and in consultation with a committee of the Board of Agriculture on January 30th a rough draft of a bill was prepared. By request of Colonel James F. Brown, Secretary of the Board, this bill was introduced by Representative Allyn of Ledyard. Later we had this measure examined by legal counsel, and while not sacrificing any of the essentials, the bill was put in better legal form and introduced as a substitute at a hearing before the agricultural committee on February 19th. This committee, after changing certain portions of the bill, reported favorably upon the substitute, but though we urged early action and explained the necessity of it, the appropriations committee refused to consider the measure before March 26th, when the bill was up for a hearing. There was no opposition to the measure except within the committee, which, after making more changes, finally reported favorably. This bill passed the House May 14th, and the following day the state entomologist went to Hartford, examined the bill, and consulting with other state officials learned that the money would not be available until July 1st, and would not be paid over by the state treasurer until the end of the quarter, or October 1st. The bill was therefore recalled, amended, and again passed the House May 15th. In due time the Senate acted favorably upon it and the Governor signed it on June 5th, making it a part of the law of the state.

The text of the new law is as follows:

THE NEW LAW REGARDING THE GYPSY AND BROWN-TAIL MOTHS.

An Act Concerning Gypsy and Brown-Tail Moths.

GENERAL ASSEMBLY,

JANUARY SESSION, A. D. 1907.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

SECTION 1. **(Public Nuisance.)** The insects commonly known as the gypsy moth and the brown-tail moth, being serious pests of vegetation, are, in all stages of their development, hereby declared to be a public nuisance.

SECTION 2. **(Authority.)** The state entomologist shall have authority to suppress and exterminate said gypsy and brown-tail moths, and may employ such assistants and laborers as he deems expedient; may cut and burn brush and worthless trees in fields, pastures, or woodlands, or along the roadsides on any public or private grounds; and may prune, spray, scrape, or fill cavities in any fruit, shade, or forest trees, or clean up any rubbish for the purpose of furthering said work. The said state entomologist, or any of his assistants, deputies, agents, or employes, shall have the right, at all times, to enter any public or private grounds in the performance of their duties.

SECTION 3. **(Living specimens must not be transported. Penalty.)** Any person transporting living eggs, larvae, pupae, or adults of the gypsy or brown-tail moths into the state, or from an infested region within the state to a region not hitherto infested, shall be fined not more than one thousand dollars or imprisoned not more than one year.

SECTION 4. **(Wilful obstruction illegal. Penalty.)** Any person wilfully obstructing or hindering said state entomologist or his assistants or employes, in the work of suppressing said insects, shall be fined not less than twenty-five nor more than five hundred dollars.

SECTION 5. **(Appropriation.)** The sum of one thousand dollars is hereby appropriated to be paid out of any money in the treasury not otherwise appropriated, for the purpose of this act for the two fiscal years ending September 30, 1909; and the board of control is hereby authorized, if said board deem it advisable, to increase said appropriation to such amount not exceeding in the aggregate the sum of ten thousand dollars as, in the opinion of said board of control and the state entomologist, is necessary, said sum to be in addition to the total amount to which said board of control is limited by law.

SECTION 6. This act shall take effect from its passage, and the appropriation provided for in section five shall become immediately available for the purpose of this act.

Approved June 5, 1907.

PROVISIONS OF THE LAW.

An examination of the preceding measure will show that the State of Connecticut has by statute provided for the control of the gypsy and brown-tail moths. First it declares these insects to be a public nuisance. The state entomologist is thereby given authority to employ the necessary help; to enter any public or private grounds; to cut and burn brush and worthless trees; to prune, scrape, spray or fill cavities in trees, or clean up rubbish. Anyone wilfully hindering the suppression work is subject to prosecution and a heavy fine.

Anyone bringing these insects alive into the state, or from an infested region within the state to a locality not hitherto infested, is liable to be heavily fined and imprisoned, and it makes no difference whether the insects are in the egg, caterpillars, cocoon or adult stages.

This law further provides an appropriation for carrying on the work, and that the act take effect immediately upon its passage.

The text of the law with explanations was immediately printed as Bulletin of Immediate Information No. 5, and a copy distributed at every house within the infested region, and was also published in the local newspapers.

Legislation and Appropriations for Gypsy Moth Work in other States.

Connecticut was not alone in enacting new laws for the suppression of the gypsy and brown-tail moths. In Maine and New Hampshire, where such legislation did not previously exist, new laws were passed in the winter or spring of 1907, giving authority and appropriations for carrying on the work. In Rhode Island, where a small appropriation had been made and expended the preceding year, the law was renewed and strengthened and a much larger appropriation granted. In Massachusetts, the state most seriously infested, the appropriation was renewed. In addition to these state appropriations Congress appropriated a large sum of money to be used by the Bureau of Entomology of the United States Department of Agriculture in coöperation with the authorities of the five infested states. The following figures give the approximate area infested by the gypsy moth and the amount appropriated for suppressing both gypsy and brown-tail moths in each state:

State.	Area Infested.	Appropriation.
Connecticut	1 square mile	$ 10,000 (biennial)
Maine	228 “ miles	30,000 (annual)
Massachusetts	3,000 “ “	300,000 (biennial)
Rhode Island	25 “ “	10,000 (annual)
New Hampshire	1,500 “ “	25,000 (biennial)
United States		150,000 (annual)
Total	4,754 “ “	$525,000

In addition to the amounts given in the preceding table, the laws of Maine, Massachusetts and New Hampshire, require that individual owners, town and municipal authorities, take measures, when necessary, to suppress these pests on their own property, or that under their charge, the expenditures not to exceed a certain low percentage of the assessed valuation of the property. On proof that this has been properly done by cities and towns, the commonwealth may reimburse the cities and towns for a certain proportion of such sums expended in accordance with the law. In this respect, the laws of Maine and New Hampshire are based on the Massachusetts law, but in Rhode Island and Connecticut the suppression work is done entirely by state and government authorities, city, town, and private owners not being obliged to act, because extermination and not mere suppression is the end in view. Should these states ever become generally infested, a measure similar to that in Massachusetts would be necessary to control the pest, and would doubtless be enacted. In addition to the $300,000 appropriated by the Massachusetts Legislature, the sum of $25,000 was made available for experimental work on parasites of gypsy and brown-tail moths. Thus according to Superintendent Kirkland the money expended by the state, by towns and individual owners in the work of suppressing the gypsy and brown-tail moths in Massachusetts in 1907, amounted to a total of nearly three-quarters of a million dollars.

Introduction of Parasites.

Many species of parasites of gypsy and brown-tail moths have been introduced into Massachusetts by Dr. L. O. Howard in coöperation with Mr. Kirkland. Dr. Howard has made three annual trips to Europe and enlisted the aid of European entomologists in the work of collecting parasitized material and sending it to this country. Parasites have been reared from this material at Mr. Kirkland's laboratory, and all hyperparasites destroyed before liberating them. The prospects for relief from this source are most promising, but it will be several years, perhaps, before the value of these parasites can be determined as a control measure. In the meantime, the other work should be continued, until it has been shown that the natural enemies alone are able to reduce the number of gypsy and brown-tail moths so materially that little or no damage will be done to property by them.

PRESENT CONDITIONS AND NECESSARY WORK FOR THE FUTURE.

The preceding pages give an account of the work which has been done in Stonington during the past year. What then are the conditions as they exist at present, and what is the outlook for the future?

About twice as great an area as is now infested or nearly two square miles has been cleared of brush, except that in some cases the season's growth has not been cut. Most of the neglected apple and other fruit trees have been pruned, scraped, and the cavities filled. The pest is well under control, though not yet exterminated. The conditions for exterminating the gypsy moth in Stonington are therefore much better than at any time since the infestation was discovered. But the work must not stop here. Trees must be banded for at least two years more, extreme thoroughness must be practiced in scouting for egg-masses and destroying them and in hunting for caterpillars both inside and outside of the present area known to be infested.

If funds are available, we shall prosecute the work along the most promising lines until the pest has been exterminated from within the borders of the State of Connecticut.

It should be borne in mind, however, that this work being done by the state is experimental, and is for the purpose of exterminating a dreadful pest from a small area. If the gypsy moth ever becomes widely distributed in Connecticut it will of course be necessary to enact laws compelling property owners to clean up their own land as is the case in Massachusetts.

THE BROWN-TAIL MOTH.

Euproctis chrysorrhaea Linn.

In the report of this station for 1902 (second report of state entomologist), page 165, is given a brief account of the brown-tail moth. The insect is also treated in Bulletin 153, issued in March, 1906. Though the brown-tail moth has not yet been found within the state, we may reasonably expect that it will appear in a few years at the most. It has been a companion pest of the gypsy moth in Massachusetts, New Hampshire and Maine, and in all of the states where suppression laws have been enacted for the latter pest the brown-tail moth has been included. The latter spreads much more rapidly, however, because the female can fly, and it has a different life history. Different combative measures are therefore necessary. We can exterminate the gypsy moth from small isolated areas, but not so with the brown-tail, though we can hold it in check, and nature supplies more effective controlling agents in the way of insect and fungous parasites than in the case of the gypsy moth. During the spring and summer of 1906 thousands of caterpillars in Massachusetts were killed in their nests by a fungous disease, thus materially checking the pest. This fungus, according to Kirkland,* was examined by Dr. G. E. Stone, botanist of the Agricultural College at Amherst, and pronounced *Empusa aulicae* Reichardt, a species common in Europe and often serving there as an important check to the outbreaks of the brown-tail moth.

DISTRIBUTION OF THE BROWN-TAIL MOTH IN AMERICA.

First noticed in Somerville, Mass., about fifteen years ago, this insect was supposed to be some native species, but as it increased in abundance it was brought to the attention of entomologists in 1897 and pronounced the brown-tail moth, a European pest which had doubtless been introduced into this country by accident. A special appropriation was granted the Gypsy Moth Commission for fighting this insect, but all work of the commission was discontinued in 1900 because the legislature refused to grant further appropriations. Since then the brown-tail moth has spread rapidly toward the north and east. In Massachusetts the entire eastern portion is infested nearly as far west as the Connecticut River valley. The insect is reported from Pawtucket, East Providence and Woonsocket, R. I., though it is not known what portion of the state is infested. The moth has been found in the entire southeastern portion of New Hampshire, even as far north as the White Mountains, and it has spread through the State of Maine into the Province of New Brunswick. So far it is not known to us that it has been found in Connecticut.

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*Second Annual Report of the Superintendent for Suppressing the Gypsy and Brown-Tail Moths in Mass., p. 127. 1907.

HABITS AND LIFE HISTORY.

The eggs are laid on the under side of the leaves during the latter half of July, in masses smaller and more elongated than those of the gypsy moth. They are also more reddish in color, but are covered with hairs in much the same manner, and contain about three hundred eggs each. See Plate XIV, a.

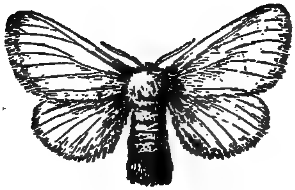

FIG. 1.—Female brown-tail moth.
(After Fernald.)

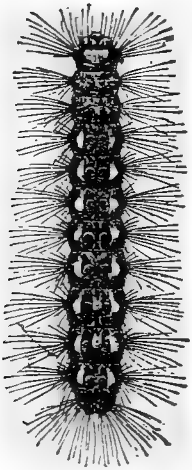

FIG. 2.—Caterpillar of brown-tail moth.
(After Fernald.)

The eggs hatch early in August, and the young caterpillars feed gregariously upon the upper leaf surface, but soon begin to fasten a number of leaves together with silken threads which they spin, forming a nest or web on the ends of the small branches. On the approach of cold weather, about 250 caterpillars enter each web, and remain there, about one-fourth grown, through the winter, coming out early in April and feeding upon the buds, and later the opening blossoms and leaves. The caterpillars (see Figure 2) become full-grown the last of June, and are between one and two inches long, dark brown in color with an interrupted white stripe on each side of the dorsum and two conspicuous red dots or tubercles on the posterior end of the body. Long hairs arise from tubercles along the sides of the body.

The cocoons are formed often in a bunch of leaves at the ends of the twigs. Two weeks is the length of the pupal or chrysalid stage, and the moths emerge usually about the middle of July.

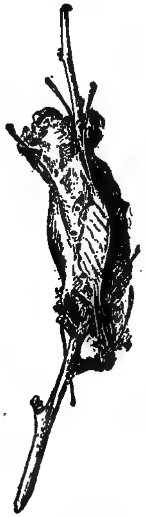

FIG. 3.—Web or winter nest of brown-tail moth.
(After Fernald.)

Both sexes are similar except that the female is larger, pure white, with brown hairs on the end of the abdomen, giving it the name of the brown-tail moth. The wing expanse of the female is about one and one-half inches. Both sexes fly at night, and are strongly attracted by electric lights. The adults, cocoons, winter nests and egg-masses are shown on Plate XIV. See also Figures 1, 2 and 3.

FOOD PLANTS.

Fernald and Kirkland give a list* of about eighty species of trees and plants on which the caterpillars are known to feed. The pear is the first preference of the caterpillars, followed by the apple and the stone fruits. Maples, elms and oaks are perhaps the chief kinds of shade and forest trees liable to be injured. As the gypsy caterpillars feed upon over six hundred different kinds of plants, it will be seen that the brown-tail is much more limited in regard to its food plants. Pear, apple and oak trees are stripped by the brown-tail caterpillars.

IRRITATION CAUSED BY THE CATERPILLARS.

The hairs of the caterpillars are barbed and brittle, and break off easily. When they come in contact with the human skin, they cause an irritation or rash which is quite serious with certain persons. The worst forms of rash are caused by actual contact with the caterpillars, but the broken hairs which blow about will cause the milder forms. The matter has been carefully studied by Dr. E. E. Tyzzer† of the Harvard Medical School, who finds in these hairs a definite poisonous principle which causes certain changes in the blood. The long hairs do not seem to possess this quality, but the short barbed hairs of the red dorsal tubercles are the ones chiefly responsible, though similar hairs occur with the long ones on various portions of the caterpillar, and on the posterior extremity of the body of the adult. In making the cocoon the hairs are rubbed from the caterpillar and woven into the new structure, and those from the adult female are worked into the formation of the egg-mass, so that either cocoon or egg-mass may produce the rash. Such hairs are doubtless cast with the skin when the caterpillars molt, and are often rubbed or broken off from their bodies and blown about, and coming in contact with the skin of human beings cause the brown-tail rash.

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* The Brown-Tail Moth, Mass. Board of Agriculture, p. 57. 1903.

† Second Annual Report of the Superintendent for Suppressing the Gypsy and Brown-Tail Moths, p. 154. 1907.

As a remedy for this rash Kirkland recommends the following, which should be well shaken together and rubbed thoroughly upon the affected parts:

Carbolic acid	½ drachm
Zinc oxide	½ ounce
Lime water	8 ounces

METHODS OF CONTROL.

The best of all remedies against this insect is the destruction of the caterpillars in the winter webs or nests, which can be readily seen at the ends of the twigs throughout the winter. These should be clipped off with a long-handled tree pruner such as is shown in Figure 4, gathered and burned. The caterpillars are hibernating in these nests from October to April. It is of no use to cut off the nests and leave them on the ground, as the caterpillars may remain uninjured and in spring crawl back to the trees.

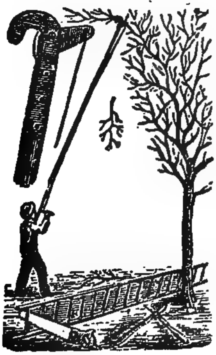

FIG. 4.—Tree pruner.

Spraying with poison is much more effective against this insect than against the gypsy caterpillar. Arsenate of lead at the rate of three pounds in fifty gallons of water is recommended for the young caterpillars, but this quantity should be increased to five pounds for the large or nearly full-grown caterpillars. Paris green at the rate of one pound in one hundred gallons may be used in place of arsenate of lead, but lime should be added to prevent injury to the foliage. Arsenate of lead causes no injury, and adheres to the foliage for a long time.

Caterpillars which are crawling about in great numbers on trees, fences, etc., should of course be destroyed. Sprinkling with kerosene, either pure or in an emulsion, or even with strong soapsuds, is of considerable value in destroying them.

Trees which are free from caterpillars may be kept so during the season by applying a sticky band to prevent the caterpillars from crawling up the trunk. Wherever the brown-tail moth becomes abundant, it must of necessity be held in check chiefly through the efforts of property owners in coöperation with town or city authorities. The problem does not require the same degree of care as is necessary in handling the gypsy moth, and therefore it is not as essential that it be done by competent men employed by the state.

MOSQUITO BREEDING CONDITIONS AT NIANTIC AND CRESCENT BEACH IN 1907.

On August 16th a letter was received from Mr. Anson T. McCook of Niantic, calling attention to the mosquito nuisance in the vicinity of Niantic and Crescent Beach, which had been worse this season than ever before, and expressing a desire to aid in abating it. By his request an examination was therefore made of the worst areas, Mr. Walden visiting the region on August 28th, and reporting as follows:

The examination here reported was made August 28th. The writer was accompanied by Mr. A. T. McCook, and the places visited were those suggested by Dr. Dart and Mr. McCook as being probable breeding areas. No attempt was made at a systematic examination.

The Fresh Water Problem.

Dodge Pond. A large fresh water pond situated a short distance west of Niantic village. The pond is partially divided into two sections. The small western section near the road is covered with lily pads, and owing to the unusual season is dry at this time. This drying up must have been gradual, leaving numerous small pools in the uneven muddy bottom which were ideal breeding places for fresh-water mosquitoes, including *Anopheles*. Stones have been dumped along the shallow edge and are overgrown with low bushes and weeds. Mosquito breeding must take place along this edge at all times during a normal season. The large easterly portion of the pond contains water and is stocked with fish. While this part of the pond was not examined, there is much brush along the edge and the conditions are probably similar to those of the small pond.

To make Dodge pond safe I would suggest that the edge be made more abrupt by filling and that any brush growing near the edge in the water be removed, so as to insure a clean edge with no small pools that cannot be visited by small fish.

The *Pataguanset River*, west of the road at this point, was examined for a short distance. This stream has clean edges and should be free from mosquito breeding. About one hundred feet west and parallel to the river is a swampy area, apparently without good drainage. Draining this into the river would do away with a possible *Anopheles*-breeding area.

Middle Pond. This pond at Crescent Beach was examined. A driveway cuts it off from the salt water, but a large drain extends under the driveway, through which, I was told, the tide comes in. I was afterwards informed that there is a gate in the drain keeping the tide out and that the pond contains fresh water. Fish were numerous and no mosquito larvae were observed. If this is maintained as a fresh-water pond the edge should be watched more carefully than would be necessary if it was washed by the tide.

Lower Pond. A large fresh-water pond south from Middle pond. At the north end is a cat-tail and sphagnum swamp extending northward and then easterly around an area of higher land called the "Island" (?) and connecting with the Middle pond. The edge around the rest of Lower pond is clean and in good condition. A portion of the swamp along the east side was examined and no suspected breeding places were observed. Where the driveway crosses this swamp to reach the "Island" is a bridge over a small ditch which extends into the Middle pond. The ditch has long been neglected and consists merely of a series of small pools which were found to contain larvae of *Culex*. This drain should be opened at least from the bridge to the Middle pond. This would drain the low area east of the bridge, which is now in a soggy condition.

This section should be examined in a normal season to best judge the conditions.

THE SALT MARSH PROBLEM.

The east side of the Pataguanset marsh from the railroad south was viewed from the road and a section at the lower end was examined. Most of the small pools contained fish or were reached by the tide. No mosquito larvae were found.

The marsh on both sides of the bridge where the Old Black Point road crosses the Pataguanset river was examined. On the south side of the bridge and east of the river the marsh is in a very soggy condition. The old ditches are choked and there are numerous pools of standing water, nearly all containing large number of wrigglers of the salt marsh mosquito, *Culex sollicitans*. A short distance from the bridge a small point of the marsh extends inland. This area contains a number of depressions where the water has dried out, and the mud is covered with dead larvae. This place would probably be more serious in a normal season. It could be drained by cleaning out an old ditch which extends towards this point from the river. and continuing it for about one hundred and fifty feet. This marsh should be examined southward as far as the railroad, and where breeding is found ditches should be dug to the river.

The east side of the river north of the bridge is also in a serious condition and needs ditching. Many pools with a large number of larvae were found here. Further to the north the marsh extends around a point of land and reaches nearly to the road. This area contains several large pools with very few fish in them. Mosquito larvae were present in great numbers. An old choked ditch extending in from the river is not connected with any of these pools. It should be cleaned and extended for about one hundred feet. It will probably be necessary to dig two or three lateral ditches on each side of this main ditch to drain the area. The marsh west of the river was not examined but appears to be in a similar condition to that on the east side.

The ditches recommended for draining this marsh should be from six to twelve inches wide and about two feet deep. Good drainage should be secured by placing the ditches one hundred feet apart. Without taking any measurements, I should judge that about one thousand feet of ditch would be required to drain the area examined. There are already a few ditches which could be cleared and deepened. Probably a good laborer could put the area in a safe condition in about eight or ten days.

The mosquito larvae found in these various pools were about full-grown, and to destroy these I would recommend the use of kerosene oil. This can be applied with a watering pot having a fine rose.

Mr. McCook soon oiled the worst areas, with satisfactory results, but no draining was attempted. It is usually possible, by the expenditure of moderate sums of money in draining and filling, to do away with the wholesale breeding of mosquitoes. The inhabitants of each neighborhood should coöperate to make the locality as attractive as possible—and one of the first things to be done in each settlement along the Connecticut coast is to abolish the pools of stagnant water where mosquitoes breed. If permanent ditching cannot be started, oiling the pools will afford temporary relief, but in order to be effective it should be repeated once in ten days or two weeks during the mosquito season.

THE CHEMICAL COMPOSITION OF LEAD ARSENATE AND PARIS GREEN.*

By John Phillips Street.†

The constantly increasing use of insecticides in various spraying mixtures makes the effectiveness and the cheapness of the poisons used a matter of considerable practical importance. Paris green has been more commonly used for many years than any other arsenical insecticide, and has proved very effective. There is, however, a certain serious objection to its use; the partial solubility in water of the arsenious oxide, which frequently causes damage to foliage. For this reason entomologists have sought a different poison, which would be effective against insects, harmless to plants, and economical for the farmer to use. Lead arsenate seems to meet these requirements, and possesses a still further advantage over Paris green in that its mechanical condition keeps it longer in suspension in the spraying mixture. There are a number of brands of this material on the market, varying greatly in appearance and consistency, and it was considered advisable to make a somewhat extended chemical examination of them to determine their relative value. As the various brands of Paris green on sale in this State had never been analysed at this station, they also have been included in this examination.

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* This paper, with the directions following it by Mr. Britton, was printed as Bulletin 157 and distributed in September. It is here placed in more permanent form with slight emendations.

† The analyses of Paris green have been made by Messrs. E. M. Bailey and E. J. Shanley; those of lead arsenate by the writer.

METHODS OF ANALYSIS.

In the analysis of lead arsenate the method proposed by Haywood* has been followed in all particulars, and has proved very satisfactory. With Paris green the same methods as used by the writer† in a similar examination at the New Jersey Station have been followed. In addition, however, a test of the water-solubility of the arsenious oxide was made by the official A. O. A. C. method,‡ treating the green with distilled water for ten days.

LEAD ARSENATE.

Ten of the eleven samples analysed were taken from the museum stock of Dr. Britton, the State entomologist, but were recently acquired and were believed to be representative; the duplicate sample of Swift's arsenate was bought in the open market. The samples were received in containers of various sizes and material, from a one-pound glass jar to a fourteen pound wooden bucket. The material itself showed striking differences in consistency. Disparene settled out completely, leaving a supernatant liquid filling from one-fourth to one-third of the vessel; the Target brand and Swift's also showed some separated liquid, while the others were more of the consistency of putty and quite homogeneous.

The samples analysed were as follows:

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* U. S. Dept. of Agr., Bur. of Chem., Bull. 105, 165.
† New Jersey Expt. Station, Bull. 195.
‡ U. S. Dept. of Agr., Bur. of Chem., Circ. 10, 3.

19210. Eagle Brand. Adler Color & Chemical Co., New York.

19212. Target Brand. American Horticultural Distributing Co., Martinsburg, W. Va.

19211. Disparene. The Bowker Insecticide Co., Boston, Mass.

19216. Star Brand. Fred. L. Lavanburg, New York.

19215. Anchor Brand. Leggett & Bro., New York.

19213. Swift's Arsenate. Merrimac Chemical Co., Boston, Mass.

18703. Duplicate of No. **19213**, purchased in market.

19643. Arsenate of Lead. Monmouth Chemical Works, Shrewsbury, N. J.

19357. Arsenate of Lead. The Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

19358. Aiboneta. Schoonmaker & Son, Cedar Hill-on-Hudson, N. Y.

19209. Arsenate of Lead. The Vreeland Chemical Co., 123 Maiden Lane, New York. (Factory at Little Falls, N. J.)

ANALYSES OF ARSENATE OF LEAD.

Station No.	Brand.	Original Material.						Water-Free.		
		Water.	Arsenic Oxide (As_2O_5).	Lead Oxide (PbO).	Soluble Impurities (other than As_2O_5 and PbO).	Insoluble Impurities (by difference).	Soluble Arsenic Oxide.	Arsenic Oxide (As_2O_5).	Lead Oxide (PbO).	Total Impurities.
19210	Eagle	54.55	14.89	28.46	0.32	1.78	0.46	32.76	62.62	4.62
19212	Target	50.30	12.30	34.03	2.73	0.64	1.31	24.75	68.47	6.78
19211	Disparene	46.47	13.87	35.11	4.34	0.21	0.39	25.91	65.59	8.50
19216	Star	50.57	12.64	35.63	0.47	0.69	0.51	25.57	72.08	2.35
19215	Anchor	35.59	17.11	44.05	2.02	1.23	0.86	26.56	68.39	5.05
19213	Swift's	49.95	14.91	33.08	0.80	1.26	0.57	29.79	66.09	4.12
18703	"	48.40	15.19	33.78	0.88	1.75	0.30	29.44	65.47	5.09
19643	Monmouth	58.44	11.29	25.59	1.41	3.27	0.50	27.17	61.57	11.26
19357	Powers-Weightman	51.79	11.42	33.70	2.69	0.40	0.22	23.69	69.90	6.41
19358	Aiboneta	41.95	11.72	37.90	7.94	0.49	0.42	20.19	65.29	14.62
19209	Vreeland	33.65	21.91	41.44	0.74	2.26	0.86	33.02	62.46	4.52

RESULTS OF ANALYSES.

The analyses show lead arsenate to be far from a uniform material; the arsenic oxide ranges from 11.29 to 21.91 per cent., and the lead oxide from 25.59 to 44.05 per cent. The soluble arsenic oxide was low in all cases, ranging from 0.22 to 1.31 per cent., and this after a treatment for ten days. No soluble lead oxide was found in any of the samples. The nature of the impurities was not determined in any case; **19210, 19358, 19643** and **19357**, however, showed traces of nitrates. The impurities were not high except in three samples, **19211, 19643** and **19358**; neither Disparene nor Aiboneta was sold as pure lead arsenate and therefore cannot be considered adulterated; the Monmouth sample, however, was sold as a pure material; in addition to its high content of impurities, it also contains the lowest percentages of both arsenic and lead oxides.

Lead arsenate is usually prepared by the action of lead acetate on disodium arsenate; some manufacturers, however, substitute lead nitrate for the acetate. Smith* has shown that the commercial grades of sodium arsenate and lead acetate and nitrate vary considerably. He found the lead oxide in lead acetate varied from 58.81 to 66.80 per cent., and in lead nitrate from 66.37 to 68.37 per cent.; while in sodium arsenate the arsenic oxide varied from 36.77 to 47.80 per cent. The calculation of the theoretical composition of commercial lead arsenate is, therefore, attended with some difficulty. Haywood,† however, has shown that, with pure chemicals, where lead acetate is used the theoretical composition should be 74.40 per cent. lead oxide and 25.60 per cent. arsenic oxide; and where lead nitrate is used, 64.26 and 33.15 per cent., respectively. The methods used in the above analyses give results very close to theory where the lead arsenate is prepared from lead nitrate, but where lead acetate is used slightly higher than theory for arsenic oxide and slightly lower for lead oxide, indicating that probably some secondary reaction takes place during the process of manufacture, resulting in the formation of some compound other than lead arsenate, probably an acid lead arsenate. By referring to the analyses of the samples on the water-free basis, it appears that **18703, 19209, 19210, 19213** and **19643** are made from lead nitrate, the others from lead acetate. Formerly it was the practice to add glucose to increase the adhesive power of the arsenate, but it has been shown that it adheres almost as well without glucose as with it, and its use has been largely discontinued.

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* Agr. Massachusetts, 1897, 357–369.

† U. S. Dept. of Agr., Bur. of Chem., Bull. 105, 168.

Allowing for the variations in process of manufacture, it would seem, however, that the content of arsenic oxide in the various commercial lead arsenates was conditioned more by the wetness of the material than anything else; the content of water in the samples analysed ranged from 33.65 to 58.44 per cent. A perfectly dry material has not been found advantageous, for while even in such a form it remains in suspension several times as long as the finest Paris green, it settles about three times as fast as when the arsenate is used in the form of a paste. On the other hand, the paste must not be too tenacious or it will be difficult to break up and distribute evenly throughout the spraying mixture. Colby* has found this objection to hold with Disparene. In making the water-soluble determinations it was observed that there were marked variations in the rate of settling even when the samples were in the dry and powdered condition. It is probable that the same peculiarity would have been noted in the samples in their original state, but as in most cases the whole sample had already been dried, verification of this supposition was impossible.

HOME-MADE LEAD ARSENATE.

It has frequently been recommended that farmers prepare their own lead arsenate as they need it. Colby† recommends the following formula: Dissolve 24 oz. of lead acetate or 20 oz. of lead nitrate in one gallon of cold water; also separately dissolve 10 oz. sodium arsenate in three quarts of water, both solutions to be made in wooden vessels. Pour the separate solutions into the spray tank containing from 100 to 150 gallons of water; a white precipitate of lead arsenate immediately forms. This preparation may be made several times stronger without the least danger of injury to the foliage. The freshly precipitated home-made arsenate seems to keep in suspension better than even the best commercial preparations.

COST OF LEAD ARSENATE.

As stated before, only one of the samples was bought in the open market; the prices have therefore not been affixed in any case. By correspondence with the manufacturers the Station received quotations as follows: In 100 lb. kegs, from 9.5 to 13 cents per lb.; in 5 to 20 lb. buckets, from 11 to 16 cents per lb.; and in 1 lb. cans from 11.5 to 17 cents per lb. The advantage of purchasing in quantity is apparent.

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* California Expt. Station, Bull. 151.
† Loc. cit.

ITS ADVANTAGES.

Lead arsenate is very effective against leaf-eating insects. Its chief advantages over Paris green are its greater adhesive power and its harmlessness to the foliage. A single treatment of lead arsenate will adhere to the foliage for a period during which two or three sprayings with Paris green would be necessary to secure the same effect. The insolubility of its arsenic makes possible the use of large quantities without danger even in inexperienced hands. From the standpoint of effectiveness lead arsenate, although containing but from one-third to one-fourth as much actual arsenic as Paris green, is nearly as economical as the latter poison when sold at the same price. Purchased at the wholesale quotations noted elsewhere, and considering the duration and safety of its action, it is actually somewhat cheaper than Paris green. Furthermore, its greater power of suspension makes it more easily used and insures a more uniform distribution of the poison over the plant.

PARIS GREEN.

There is no law in this State regulating the sale of Paris green, but where a state inspection is in effect the requirements are generally very similar to those in the New Jersey law,* section 3 of which reads:

> "Paris green, or any product analogous to it, when sold, offered or exposed for sale as such, in this State, shall comply with the following requirements:
>
> "First. It shall contain arsenic, in combination with copper, equivalent to not less than fifty per centum arsenious oxide.
>
> "Second. It shall not contain arsenic in water-soluble forms equivalent to more than three and one-half per centum of arsenious oxide."

Many analyses of Paris green have been made by the various Experiment Stations, showing the green to be of variable composition. These variations are chiefly due to different methods of manufacture or carelessness in carrying out the same. In many cases a large amount of the arsenic exists as free arsenious oxide, which may arise from intentional addition of white arsenic, as well as from careless manufacture. This is a serious adulteration, for white arsenic is a cheaper material, and its solubility in water renders its presence in anything but small quantities a source of much danger to foliage from scorching. Other adulterations have been detected, but the one just referred to is the most prevalent and most objectionable.

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* New Jersey Expt. Station, Bull. 195.

Paris green is essentially copper aceto-arsenite, and, if pure, should contain an equivalent of 58.65 per cent. arsenious oxide, 31.29 copper oxide and 10.06 acetic acid. The commercial article, however, usually contains small quantities of moisture and sand and varying amounts of sodium sulphate.

Twelve samples, representing eight manufacturers, were purchased from dealers by the Station sampling agent. A description of these follows:

19481. Made by A. B. Ansbacher & Co., New York. Sold by Lyon & Ewald, New London.

18662. Made by A. B. Ansbacher & Co., New York. Sold by the Sisson Drug Co., Hartford.

18634. Made by E. J. Barry, New York. Sold by Odell's Pharmacy, New Britain.

18509. Made by E. J. Barry, New York. Sold by J. H. & W. E. Cone, Hartford.

18704. Made by James A. Blanchard, New York. Sold by F. S. Platt, New Haven.

19547. Made by Morris Hermann & Co., New York. Sold by D. B. Wilson Co., Waterbury.

18569. Made by Leggett & Bro., New York. Sold by Lockwood & Palmer, Stamford.

18508. Made by Leggett & Bro., New York. Sold by M. H. Mallett, New Milford.

18512. Made by I. Pfeiffer, New York. Sold by Frank M. West, Bridgeport.

18510. Made by C. T. Raynolds & Co., New York. Sold by H. K. Brainard, Thompsonville.

18511. Made by C. T. Raynolds & Co., New York. Sold by Danbury Hardware Co., Danbury.

18663. Made by The Sherwin-Williams Co., Newark, N. J. Sold by R. E. Page, Hartford.

ANALYSES OF PARIS GREEN.

Station No.	Manufacturer.	Cost of Package.	Weight of Package.		Arsenious Oxide. (As_2O_3).			Copper Oxide. (CuO).	Arsenious Oxide combined with copper.
			Claimed.	Found.	Total.	Water-Soluble. 1 day.	Water-Soluble. 10 days.		
		cts.	oz.	oz.	%	%	%	%	%
19481	Ansbacher	13	* 4	3.6	57.92	1.46	2.92	28.76	53.78
18662	“	10	4	4.0	57.44	0.97	2.44	29.49	55.15
18634	Barry	35	*16	14.5	57.23	1.71	6.82	29.55	55.26
18509	“	18	* 8	8.0	56.62	2.44	6.82	29.01	54.25
18704	Blanchard	10	4	5.0	57.03	2.44	7.31	28.14	52.62
19547	Hermann	18	* 8	7.6	56.20	2.44	4.87	28.54	53.37
18569	Leggett	10	* 4	3.6	60.61	5.85	10.72	27.15	50.77
18508	“	20	8	7.3	56.83	2.92	8.77	29.34	54.87
18512	Pfeiffer	20	8	8.0	56.71	1.46	4.38	30.27	56.60
18510	Raynolds	28	*16	15.4	60.83	1.95	6.32	26.56	49.63
18511	“	10	* 4	4.0	61.19	2.44	9.74	27.15	50.77
18663	Sherwin-Williams	10	4	3.6	56.56	1.46	2.92	29.88	55.88

All the samples were carefully weighed with and without the container; one sample was overweight, four equalled the weight claimed, and seven were short weight. These shortages varied from 4 to 10 per cent., not large in any case, but indicating that the manufacturers' claimed weight is intended to include the weight of the container as well as the green itself, a practice without justification.

CHEMICAL ANALYSIS.

Total Arsenious Oxide. All the samples contained satisfactory amounts of total arsenious oxide, varying from 56.20 to 61.19 per cent. with an average of 57.93 per cent.; this average is only slightly lower than the equivalent of arsenious oxide contained in pure copper aceto-arsenite. Judging, therefore, alone from the content of arsenious oxide, it would appear that the Paris green on the market in Connecticut is of high quality. A definite decision as to the purity of the green, however, cannot be reached without considering also the amount of water-soluble arsenic present.

Water-Soluble Arsenious Oxide. Free arsenious oxide is always soluble in water, and the combined arsenic is liable to be rendered soluble by prolonged treatment. Two methods for determining soluble arsenious oxide have been adopted provisionally by the Association of Official Agricultural Chemists, in one of which sodium acetate is used as the solvent, while in the other the green is treated with water for ten days. Investigations with these methods have shown that the sodium acetate method gives more closely the true percentage of free arsenious oxide, while the water-extraction method gives in addition some arsenic caused by the decomposition of the green by water. From a practical standpoint the portion of the green that is so loosely combined would in all likelihood soon break up and scorch the foliage quite as badly as would free arsenious oxide. The water-extraction method would seem, therefore, to indicate more accurately the probable effect of the green on foliage.

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* Weight printed on label; in all other cases the weight is assumed from the size of package and price asked.

The provisional method of the A. O. A. C. requires treatment with water for ten days, but it has been pointed out that the usual practice among horticulturists is to mix the green with water not very long before they wish to use it. For this reason certain Stations, for instance New York, California and New Jersey, have adopted a one-day extraction period, which it is believed gives results more in harmony with actual practice. This Station has likewise adopted this method in the present work, and analyses by both the one-day and ten-day extractions are given in the table for comparison. The analyses clearly show that, if the ten-day method is to prevail as a standard, but three of the samples would fall within the usual legal limit of three and one-half to four per cent. of soluble arsenious oxide. With the one-day method, but one sample, **18569**, contains an excessive amount, 5.85 per cent. This sample varies greatly in composition from a duplicate sample from the same manufacturer, and under the microscope clearly shows the presence of white arsenic. The use of this sample would be exceedingly dangerous to foliage.

Copper Oxide. The amount of cupric oxide found in the samples varied from 26.56 to 30.27 per cent., with an average of 28.65 per cent. In pure copper aceto-arsenite the ratio of arsenious oxide to copper oxide is as 1.87 is to 1.00. This ratio is of value in assisting to determine whether white arsenic has been used to fortify the green, for arsenious oxide cannot be added without increasing the ratio. In the samples analysed, the ratio varied from 1.87 to 2.29; the high ratio shown in sample **18569** gives additional evidence of the presence of considerable quantities of white arsenic. The amount of arsenious oxide in combination with copper varied from 49.63 to 55.88 per cent., with one exception above the usual legal requirement of 50 per cent. In three of the samples the amount of arsenious oxide is more than 2.20 times that of the copper oxide, and the natural inference is that either arsenic has been added purposely or that the material has been carelessly manufactured.

A comparison of the water-soluble arsenic in Paris green and lead acetate emphasizes one of the chief advantages gained by using the latter insecticide. In lead arsenate from 0.22 to 1.31 per cent. was soluble in ten days, while in Paris green the solubility ranged from 2.44 to 10.72 per cent.

DIRECTIONS FOR THE USE OF LEAD ARSENATE AND PARIS GREEN AS INSECTICIDES.

Lead arsenate as an insecticide was first used in the work of the Gypsy Moth Commission in Massachusetts in the early nineties and it has since been employed in controlling nearly all of the leaf-eating insects, and has proved to be a valuable addition to our list of available arsenical poisons. When devoured by insects it is somewhat slower in its action than Paris green, and should therefore be applied earlier, before much damage has been done to the plants. On account of the excellent adhesive qualities of lead arsenate, it remains upon the foliage for a long time, while Paris green soon washes off if rains are frequent. Lead arsenate is gradually replacing Paris green as an arsenical insecticide, and especially during the past season the high price of the latter has induced many farmers and fruit growers to use lead arsenate. Paris green has been used to destroy leaf-eating insects ever since the Colorado potato beetle reached the Atlantic States. It is therefore the old standard remedy, and in many places is the only arsenical insecticide that can be purchased at the stores.

FORMULA FOR LEAD ARSENATE.

As lead arsenate is sold in paste form, and even when calculated as water-free contains less arsenic than Paris green, it is necessary to use a larger quantity by weight of the commercial article to gain the desired end in spraying work. Lead arsenate can be used only in liquid form to be sprayed upon the foliage, and the usual formula is as follows:

Lead arsenate	3 lbs.
Water	50 gallons.

For sawfly larvae and some other insects that are easy to kill, one pound in fifty gallons may suffice, and in spraying to kill gypsy caterpillars five pounds in fifty gallons are the proportions considered the most effective. In spraying for elm leaf beetle larvae the poison should be directed against the under sides of the leaves. The amount of lead arsenate may be increased greatly without danger of injuring the foliage, and lime should not be added. Lead arsenate can be used in connection with Bordeaux mixture, though it is thought to be slightly less effective as an insecticide when used in this way.*

FORMULA FOR PARIS GREEN.

Paris green is put up in powder form and can be applied either dry or as a liquid. On account of the soluble acid which it contains (see page 328 of this report) there is always danger of "burning" the foliage unless some alkali is used with the poison. For this purpose lime is usually recommended, and the adhesiveness of the mixture is greatly improved by the lime. About three pounds of lime should be used for each pound of Paris green. If to be applied dry in a duster or powder gun, Paris green should be mixed thoroughly with air-slaked lime or land plaster in the following proportions:

Paris green	1 pound.
Air-slaked lime	100 pounds.

For use as a spray Paris green may be prepared as follows:

Paris green	1 pound.
Fresh quicklime	3 pounds.
Water	100 gallons.

In most orchards and potato fields Paris green is used in connection with Bordeaux mixture, and as this contains an excess of lime, no more lime is added.

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* Tests made at this Station show that the presence of the Bordeaux mixture renders the lead arsenate perfectly insoluble. This perhaps may account for its lessened poisonous effect on insects.

THE HICKORY TUSSOCK MOTH.

Halisidota caryae Harris.

During the past two years this insect has been unusually abundant in Connecticut, and leaves of fruit and shade trees were eaten by the caterpillars. Late in the fall, solitary caterpillars nearly full-grown were found feeding upon the leaves of nursery, orchard and shade trees. I have not before seen this species so abundant during a residence of nearly fourteen years in Connecticut.

The eggs are laid early in June on the under side of a leaf in the form of a broad patch about an inch in diameter. The caterpillars are very small and gregarious at first, and may be easily mistaken for the larvae of the fall web-worm or several other species. As the larvae increase in size they take on characteristic markings with each molt, until next to the last molting stage they are very striking and pretty caterpillars, being covered with white hairs ornamented with spots of black. Near each end of the body there are two pencils of long black hairs and several tufts of long pure white hairs showing at both ends and along the sides of the body. Plate XV, a. shows this stage of the caterpillars, natural size. In the last caterpillar stage (see Plate XV, b.) the larva has a black stripe on the back, with the four pencils of black hairs as described above. The other hairs are white. The caterpillar is one and one-half inches long, and is very conspicuous and striking in appearance.

When fully grown it crawls under stones, fence rails, or into some other out-of-the-way corner, and spins a few silken threads, which together with its own hairs form a thin ash-grey cocoon, oval in shape, nearly an inch long and about one-half as thick. The cocoon is shown on Plate XV, c.

The adult moth measures nearly two inches from tip to tip of wings, and is shown on Plate XV, d. The fore wings are light brown, irregularly spotted with white and with darker lines along the veins. The rear wings are white.

Wherever the caterpillars are so abundant as to defoliate trees, the proper remedy is to spray with the arsenical poisons, either arsenate of lead or Paris green, according to the formulas given on page 331 of this report.

THE ROUND-HEADED APPLE BORER.

Saperda candida Fabr.

Young apple trees are often attacked at the base and seriously injured by borers. Even large trees are attacked, but do not become devitalized and show the effects of the work of the borer like the younger and smaller trees. Especially if the young orchard be isolated and surrounded by woodland is the attack liable to be severe.

Two kinds of borers are responsible for this kind of injury to trees,—the round-headed borer, *Saperda candida* Fabr., belonging to the family Cerambycidae, and the flat-headed borer, *Chrysobothris femorata* Fabr., which belongs to the family Buprestidae. The former is much more common in Connecticut, and we believe is the chief species attacking fruit trees. Neither species is confined to orchard trees, but lives in various native trees of the fields and woodlands, the round-headed borer being especially fond of the wild thorn, mountain ash, shad bush and chokeberry, and the flat-headed species attacking many of the larger shade and forest trees.

The round-headed apple borer is found throughout the United States and Canada, at least east of the Rocky Mountains. The adult is a long-horned beetle about three-fourths of an inch long, dark grey or brownish, with two straight white stripes or bands on the back running lengthwise of the body. These bands are not quite parallel, but join on the head and are furthest apart at the base of the wing covers, coming near together again at the apex. The antennae, legs and front of the head are white. The antennae are long and slender, as is characteristic with this family of beetles. This insect, with its characteristic injury, is shown on Plate XVI.

The eggs are yellow or pale brown, three times as long as broad and three times as broad as thick, and about one-eighth of an inch long. They are laid in incisions in the bark made by the ovipositor of the adult female, the eggs being placed lengthwise the trunk. The adults appear in June, July and August, most of the specimens in the station collection being taken in June. In Connecticut, therefore, the eggs are laid during these three months. The young borer tunnels just under the bark, working downward as far as possible before winter. Though inactive during the cold weather, it again begins operations in the spring, and burrows in the sapwood throughout the season, becoming about half-grown by the second winter. As it increases in size it does more and more damage to the tree because it is more voracious and active and makes larger tunnels through the wood. The next summer, when about three-fourths grown, it tunnels into the solid wood of the tree, and as it becomes full-grown works its way outward to the bark, making a circular hole as shown on Plate XVI. Remaining in the burrow unchanged through the winter, the larva transforms to a pupa in the spring and the beetle appears during the summer. About three years are therefore required for the complete transformations of this insect. Where several larvae are at work in the same tree they often girdle and kill it. The larva is white, with brown head and black jaws, and is about one inch long when full-grown. Usually the burrows are partially filled with particles of wood or castings from the excavations, and the pupating chamber is made of this material. Some of the castings are crowded or thrown out of the burrow, and form the principal evidence of the presence of the insect. This beetle and its work is shown on Plate XVI, where about twenty large galleries were made in the wood of the trunk of a quince tree.

Many remedies have been tried but most orchardists prefer to watch their trees and dig out the borers with a knife when found. Sometimes carbon bisulphide can be injected into the burrow from an oil can and the opening stopped with clay, soap, or wax, and the borer inside will be killed. External washes and other applications are of somewhat doubtful value, and the painting of the trunks is liable to cause great injury to the trees. Covering the base of the trunk with arsenate of lead may be of some value in keeping out borers, but this has not yet been thoroughly tested. It will adhere for a long time.

MISCELLANEOUS INSECT NOTES.

Pine Leaf Scale on Hemlock. On October 23d the writer examined a hemlock tree on the estate of the late J. M. Greist in Westville which was said to be dying. Several branches on the south side of the tree were dead and leafless. Otherwise the tree appeared perfectly vigorous and the foliage was of a dark green color. Finally a few leaves were observed that did not look quite healthy, and they were found to be infested with the pine leaf scale *Chionaspis pinifoliae* Fitch. Some branches were considerably infested, and the dead ones may have been killed in this way. It was certainly difficult to find any other explanation. This insect was mentioned in Bulletin 151, page 11, and in the report for 1905, page 240, and shown on Plate II, c. It resembles the scurfy scale, and is found on the leaves of pine and spruce trees. It is becoming rather common in Connecticut, and has been observed on white pine seedlings at Windsor the past season. It has also been sent in from various parts of the state on other species of pines from cultivated grounds. I have seen no record of its occurrence on hemlock. The remedy is to spray with kerosene emulsion soon after the eggs hatch.

Willow Curculio. In Massachusetts, New York and Minnesota the willow curculio, *Cryptorhynchus lapathi* Linn., causes considerable injury to ornamental willow and poplar trees in parks and on private grounds. Previously, however, the insect has not been very common in Connecticut. On July 7th, 1905, the writer collected a specimen of this beetle from a bunch of native willows (*Salix discolor*) at Torrington. The willows had been tunneled through and through by this insect, and though of no value, were ruined. In 1906, another species of willow at Guilford was observed to be likewise injured by this beetle. During 1907 several bunches of willows near New Haven have been killed outright by its attack. This beetle is one of the snout beetles or curculios, and is shown in Figure 5.

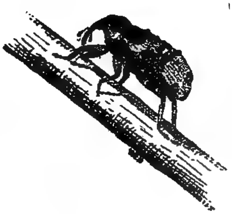

FIG. 5.—The willow curculio, twice natural size.

The Poplar Borer. While engaged in cutting and pruning trees to control the gypsy moth in Stonington, the men came across a poplar tree showing serious injury by borers. Chips or castings were falling from large galleries in the wood of the trunk. As the tree was of no value and was in such shape as to be a hindrance, it was removed. A section of the trunk was placed in a breeding cage and during August several specimens of the poplar borer, *Saperda calcarata* Say, emerged from the galleries and were killed and mounted for the collection. This beetle is one of the long-horned beetles closely related to the round-headed apple borer, and is of a mouse-grey color with yellow stripes and spots on the thorax and wing covers, and with fine black dots sprinkled over the wing covers. It is about an inch in length.

The Maple Barer. This insect, which is closely allied to the preceding, is causing serious damage to maple shade trees in Connecticut. A large proportion of the street trees in the cities and villages, as well as the shade trees along the country roads, show injury caused by this insect. The maple borer, *Plagionotus speciosus* Say, is a handsome black beetle with yellow markings, and is about an inch long. It is shown in Figure 6. The insect was studied many years ago, and the evidence gathered showed that three years are necessary for the species to develop from the egg to the adult stage, but the subject should again be investigated. The beetles emerge here usually about the first half of July, and probably soon lay their

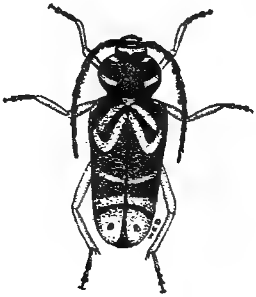

FIG. 6.—The maple borer, natural size.

eggs. The trees should be examined in the fall for the fine castings thrown out by the small larvae. Constant watching is the only safeguard, and where found, carbon disulphide will kill the insect if the burrow is stopped up so that the fumes cannot escape.

The Grape Vine Flea-Beetle. Beetles were received from Plantsville and from Danbury about the middle of May with reports that they were causing injury by eating holes into the buds, which had not then opened. This is a small dark blue beetle bearing the Latin name of *Haltica chalybea* Ill. Covering the buds with an arsenical poison like Paris green or lead arsenate will prevent injury.

The Elm Leaf Beetle. (*Galerucella luteola* Müll.) This insect was less abundant than in 1906, though made the subject of Bulletin 155, which was issued in May, 1907. This bulletin is not reproduced in this report, but will be sent to any address on application as long as the supply lasts.

An Injurious Myriapod. Specimens were received from Guilford and from North Haven of a small Myriapod or "thousand-legged worm" that had been feeding upon the roots of plants, causing considerable injury. At Guilford large buds of hardy bulbs had been attacked and destroyed by them. I have similar records of injury by this same species from Woodbridge and from Massachusetts. It was identified as *Julus hortensis* Wood, a species known to injure various plants, but apparently no experiments have been made with remedies and the literature contains few suggestions as to treatment.

A Fungus-Inhabiting Beetle. On December 7th a beetle was received from Watertown with the statement that it was found crawling about in the house. The beetle was *Boletotherus bifurcus* Fabr., a species known to inhabit shelf fungi which grow upon trees and logs. Probably a piece of fungus on fuel was brought into the house and the insect emerged from it.

The Bag-worm. This name is erroneously given to the common Tent caterpillar by many persons. The bag-worm *Thyri-*

dopteryx ephemeraeformis Steph. is an entirely different insect and is much more common in the southern states than here. Nevertheless it occurs here and is occasionally found feeding upon arbor vitae in the shore towns. Specimens of larvae with their bags of cases attached to fence posts were received from Cheshire.

The Rabbit Bot-fly. In September we received from Southport, large larvae which had been found under the skin of a rabbit below the neck. Though not familiar with this parasite I consulted Professor Osborn's paper on "Insects Infesting Domestic Animals" * and found that the larvae agreed with the description and figures of the rabbit bot-fly, *Cuterebra cuniculi* Clark.

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* Bulletin 5, new series, Division of Entomology, U. S. Dept. of Agriculture, page 108, 1896.

ILLUSTRATIONS.

The illustrations in Part V of this report are from the following sources:

Plate XV a, from photograph by D. B. Pangburn.

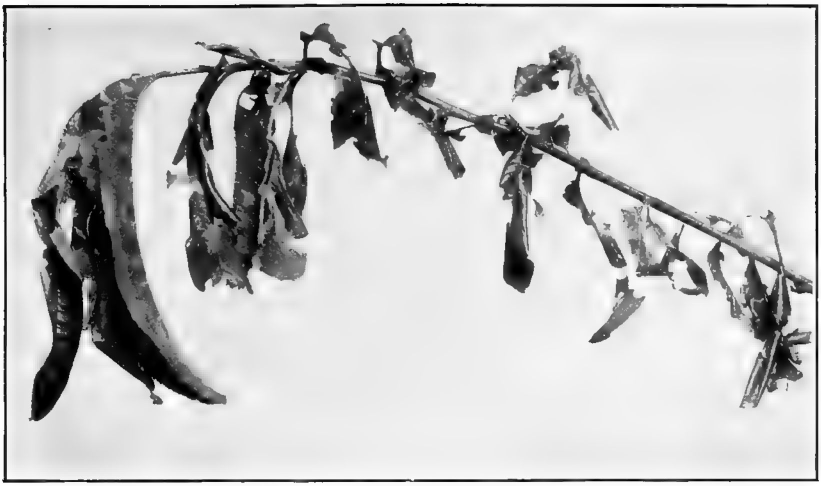
Plates VII, VIII b, IX c, X, XI, and XII from photographs by G. H. Hollister.

Plates VIII a, XIII b, XIV a, XV b, c and d from photographs by W. E. Britton.

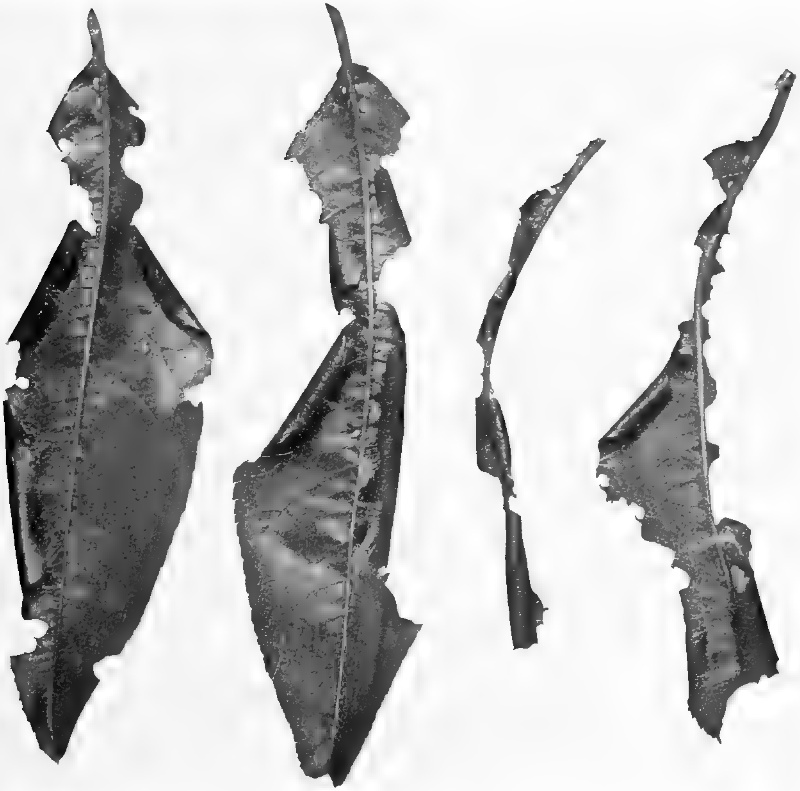
Plate III b from drawing, and all other plates from photographs by B. H. Walden.

Text figures 1, 2, 3 and 4 are from Fernald, Special Bulletin Massachusetts Agricultural Experiment Station, 1897.

Figures 5 and 6 are from drawings by W. E. Britton.



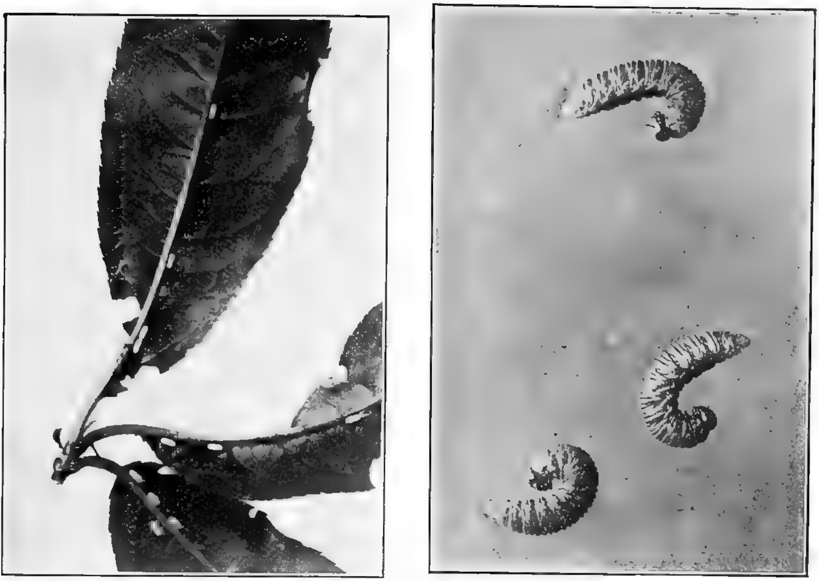
a.—Twig partially defoliated by the larvae.



b.—Leaves eaten and rolled by the larvae. Natural size.

WORK OF THE PEACH SAWFLY.

PLATE II.

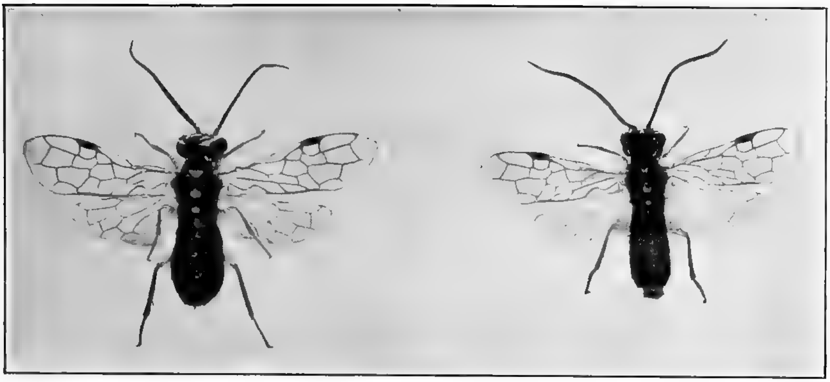


a.—Eggs on the under-side of peach leaves. Natural size.

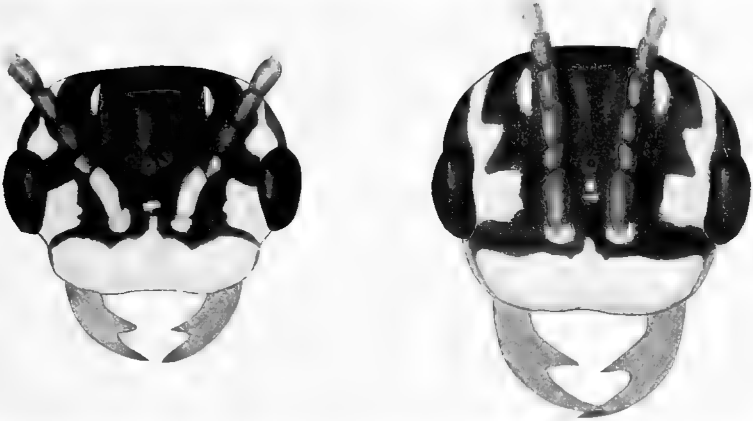
b.—Larvae. Twice natural size.

c.—Larvae taken from ground in spring. Natural size.

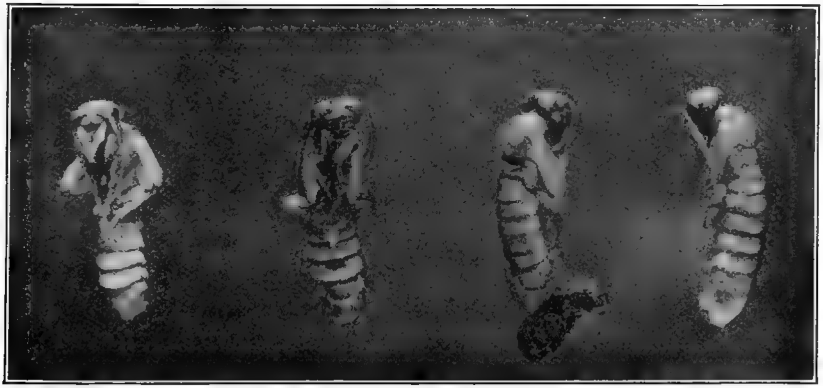
EGGS AND LARVAE OF THE PEACH SAWFLY.



a.—Adults, female at left. Twice natural size.

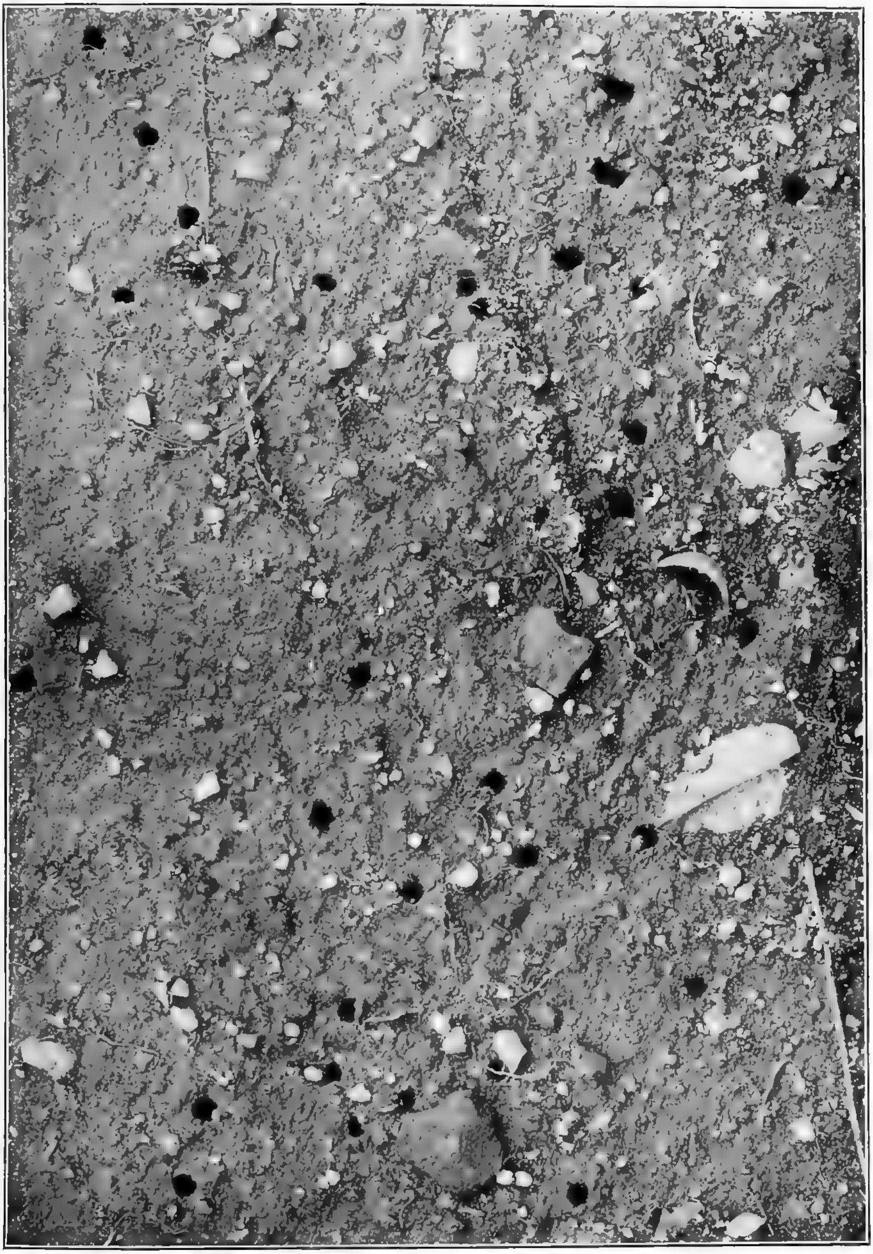


b.—Facial markings of the sexes, male at left. Greatly enlarged.



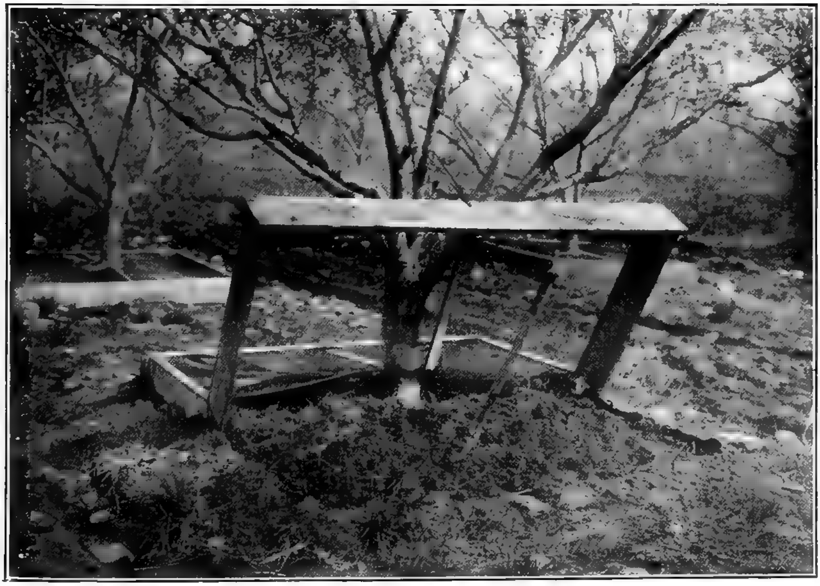
c.—Pupae. Twice natural size.

ADULTS AND PUPAE OF THE PEACH SAWFLY.



HOLES IN GROUND WHERE ADULT SAWFLIES HAVE EMERGED. NATURAL SIZE.

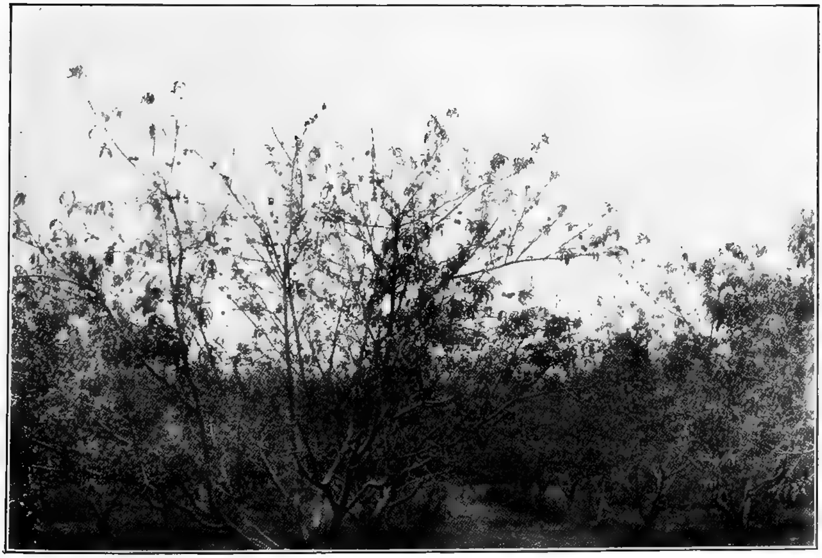
a.—General view of breeding cages.



b.—A near view showing side of breeding cage raised.

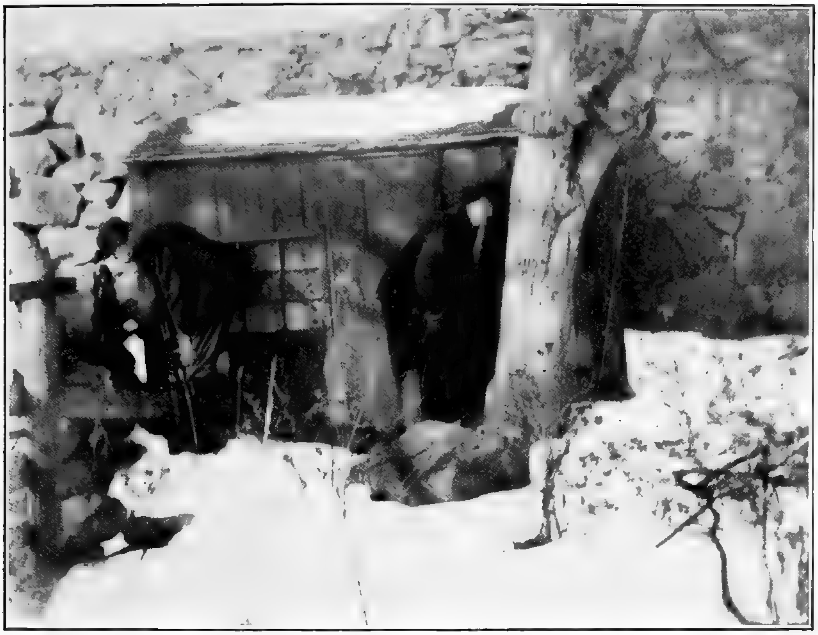
BREEDING CAGES USED IN PEACH SAWFLY EXPERIMENTS.

a.—Spraying peach trees with arsenate of lead and water.



b.—A peach tree partially defoliated.

SPRAYING PEACH TREES, AND VIEW OF DEFOLIATED TREE.

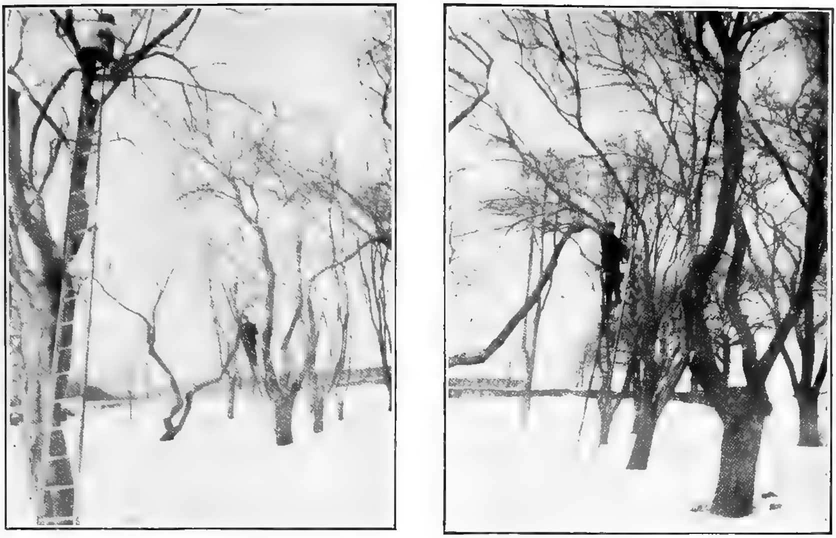


a.—Scouting for egg-masses.

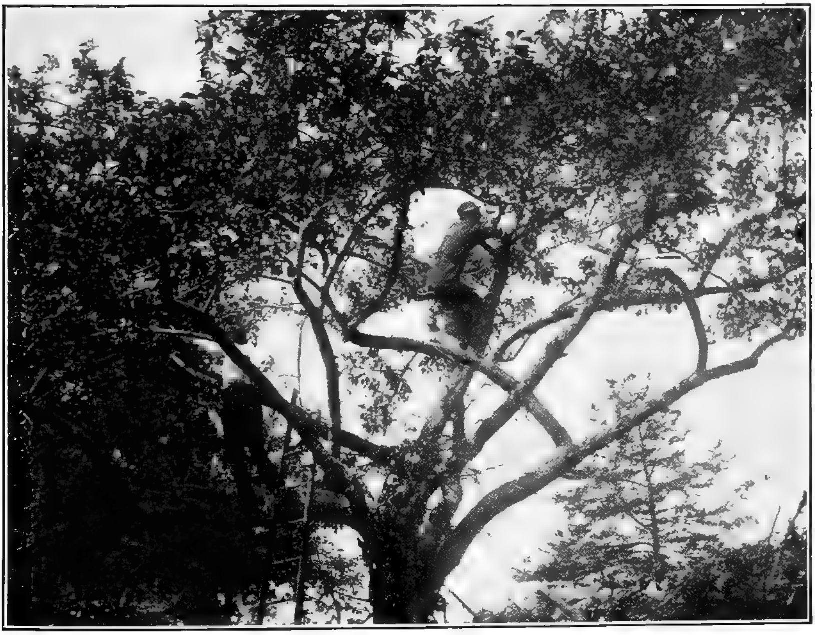
b.—Treating an egg-mass with creosote.

DESTROYING GYPSY MOTH EGG-MASSES.

PLATE VIII.

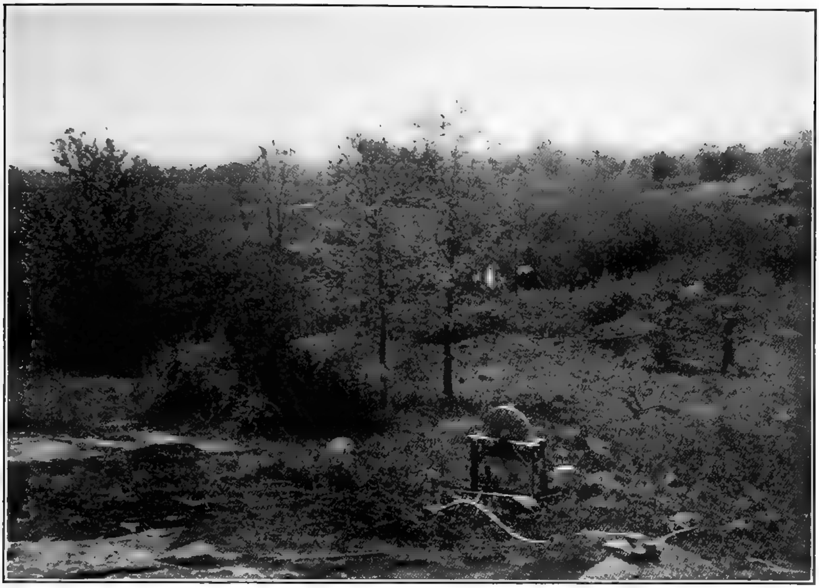


a.—Two views in Stanton orchard. Pruning trees and painting wounds.



b.—Thinning the top.

GYPSY MOTH WORK: PRUNING TREES.

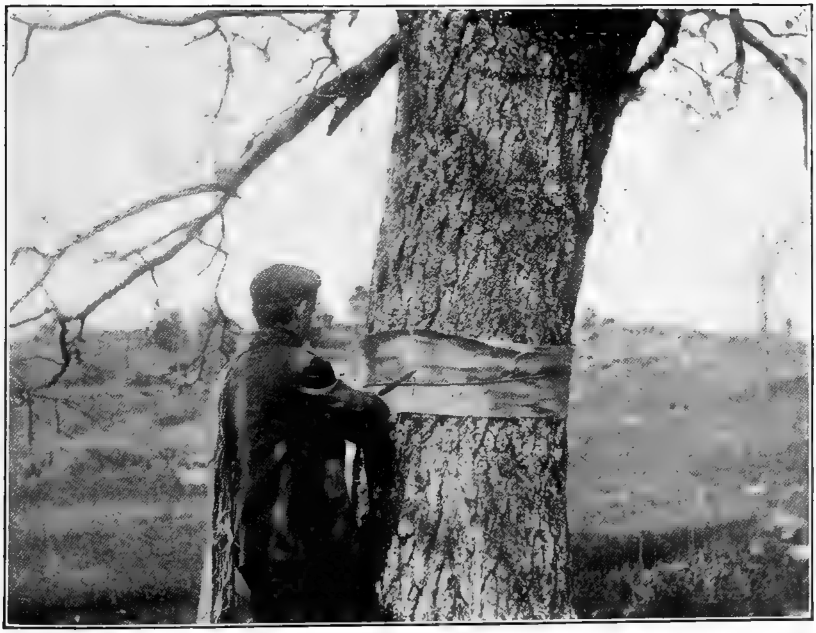


a.—Gang of workmen cutting brush.

b.—Brush area cleaned up.

GYPSY MOTH WORK: CUTTING BRUSH.

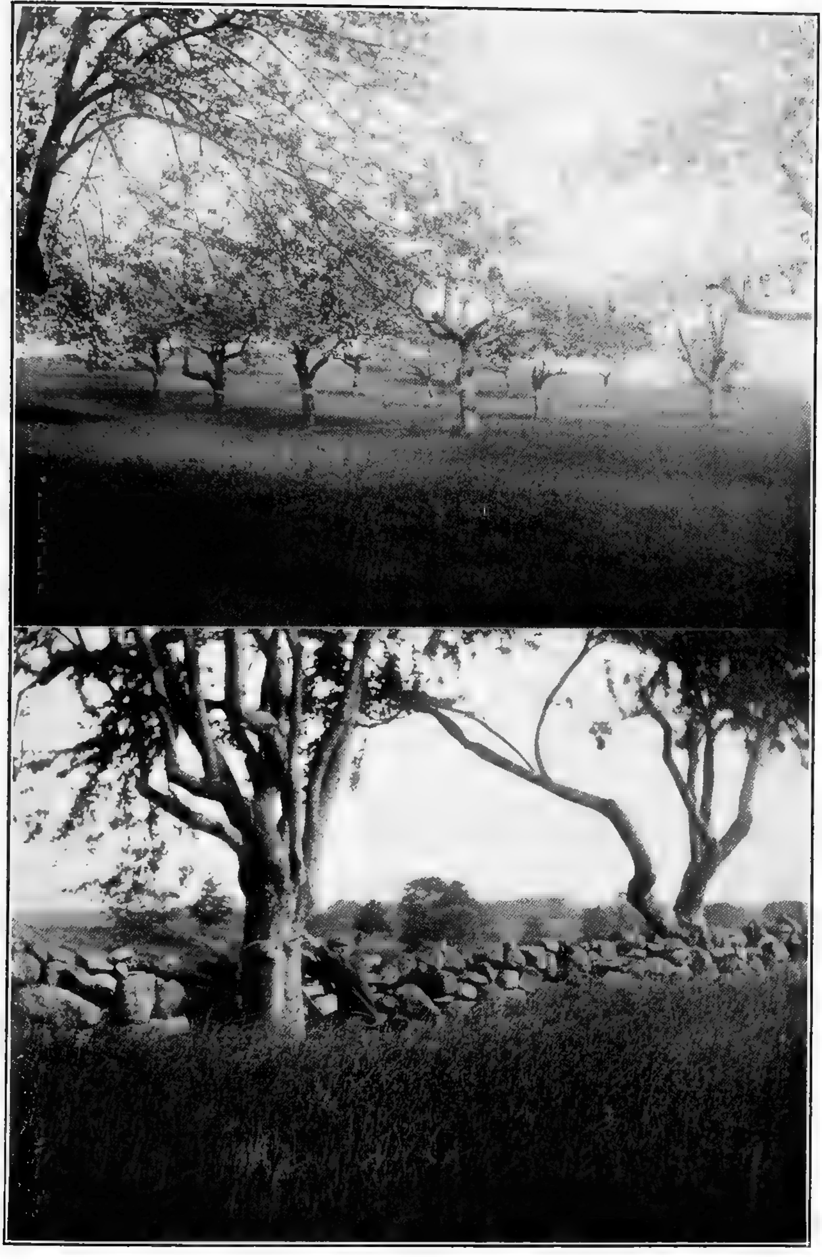
a.—Woodpile in which seven egg-masses were found.



b.—Method of applying burlap band.

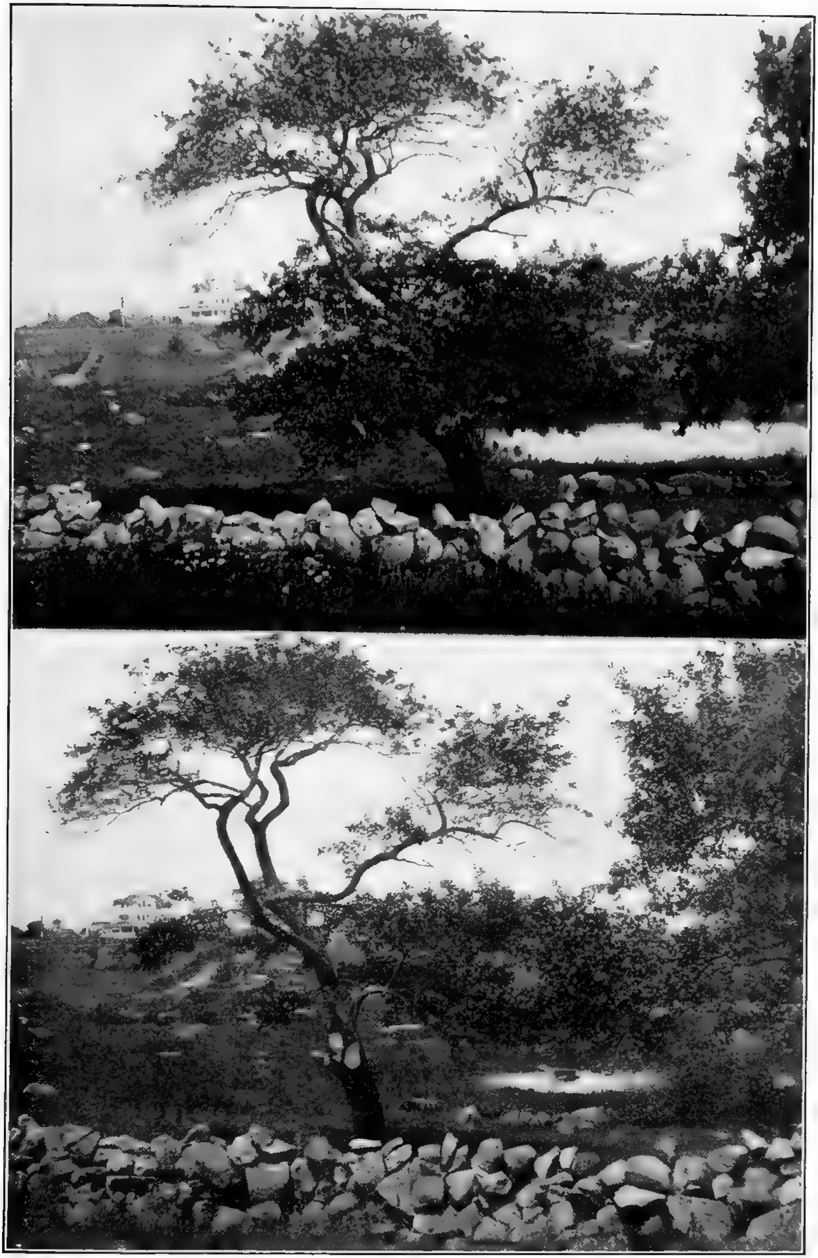
GYPSY MOTH WORK: INFESTED WOODPILE—BANDING A TREE.

PLATE XI.



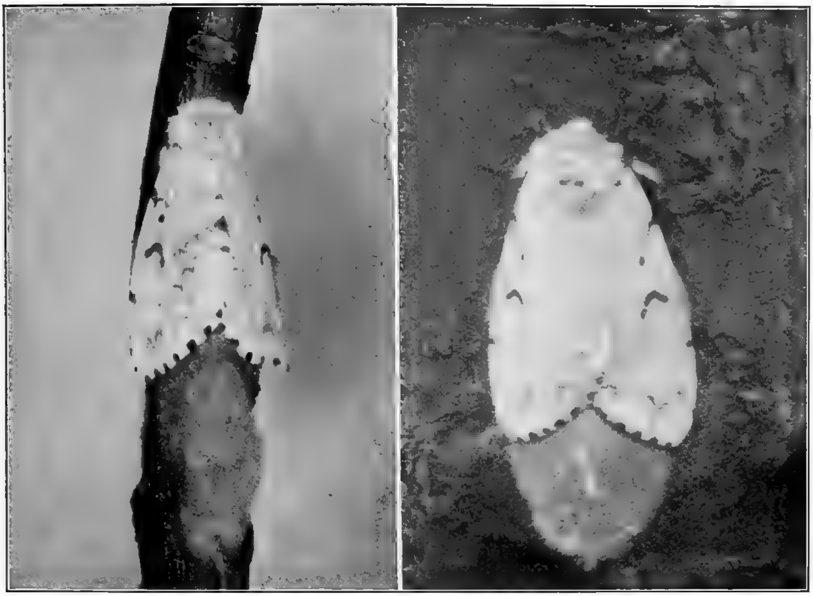
BANDED ORCHARD, AND WORKMAN EXAMINING A BAND TO DESTROY GYPSY CATERPILLARS.

PLATE XII.

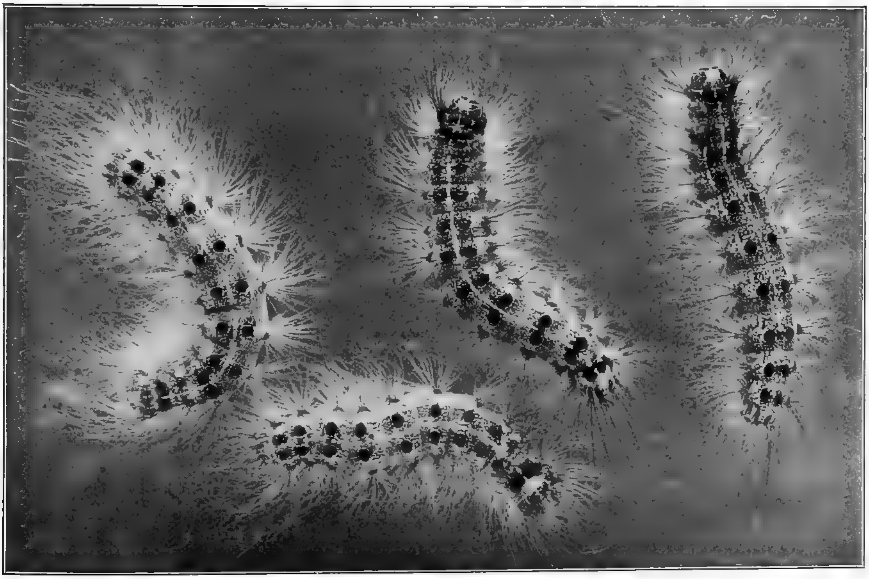


GYPSY MOTH WORK: APPLE TREE BEFORE AND AFTER PRUNING, SCRAPING AND FILLING CAVITIES.

PLATE XIII.



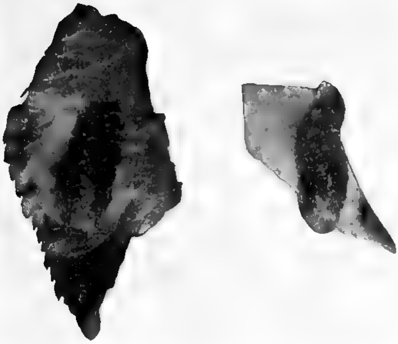
a.—Female moths laying eggs on bark. Natural size.



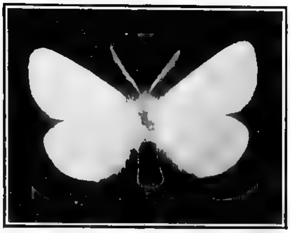
b.—Caterpillars photographed with black background.

GYPSY MOTHS, CATERPILLARS AND EGG-MASSES.

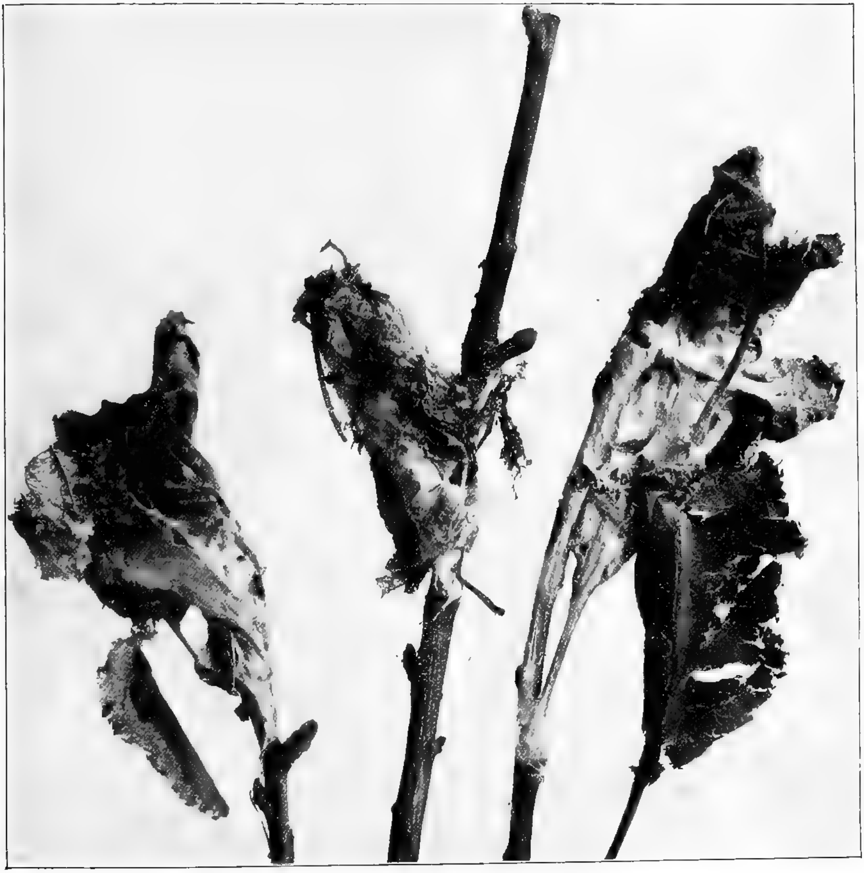
PLATE XIV.



a.—Egg-masses on leaves. Natural size.



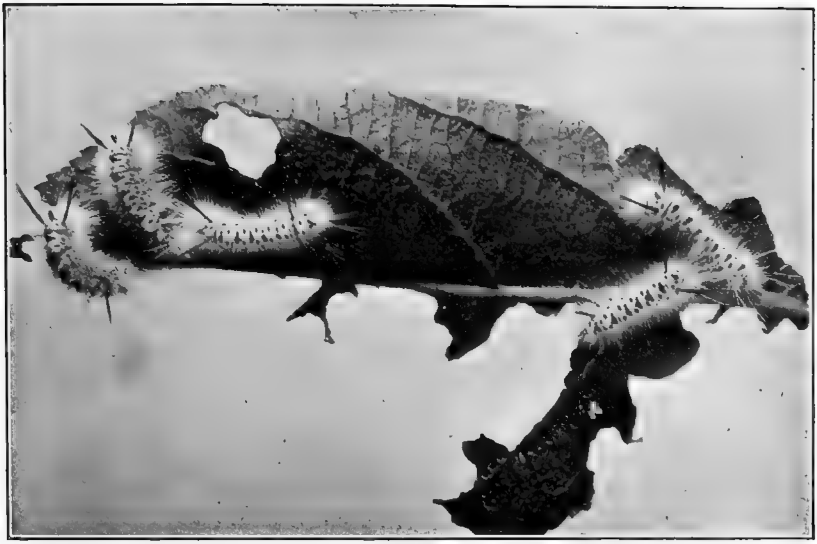
b.—Adult. Natural size.



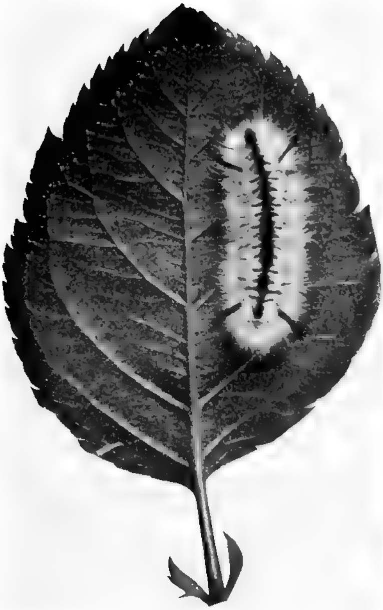
c.—Winter nests. Natural size.

BROWN-TAIL MOTH. EGG-MASSES AND WINTER NESTS.

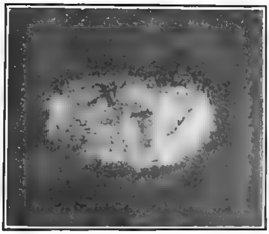
PLATE XV.



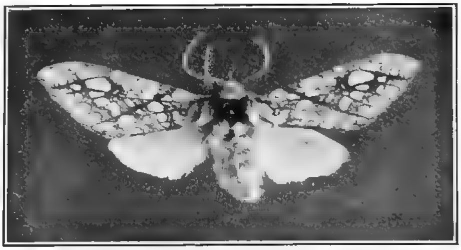
a.—Penultimate stage of caterpillars. Natural size.



b.—Fully-grown caterpillar on leaf. Natural size.



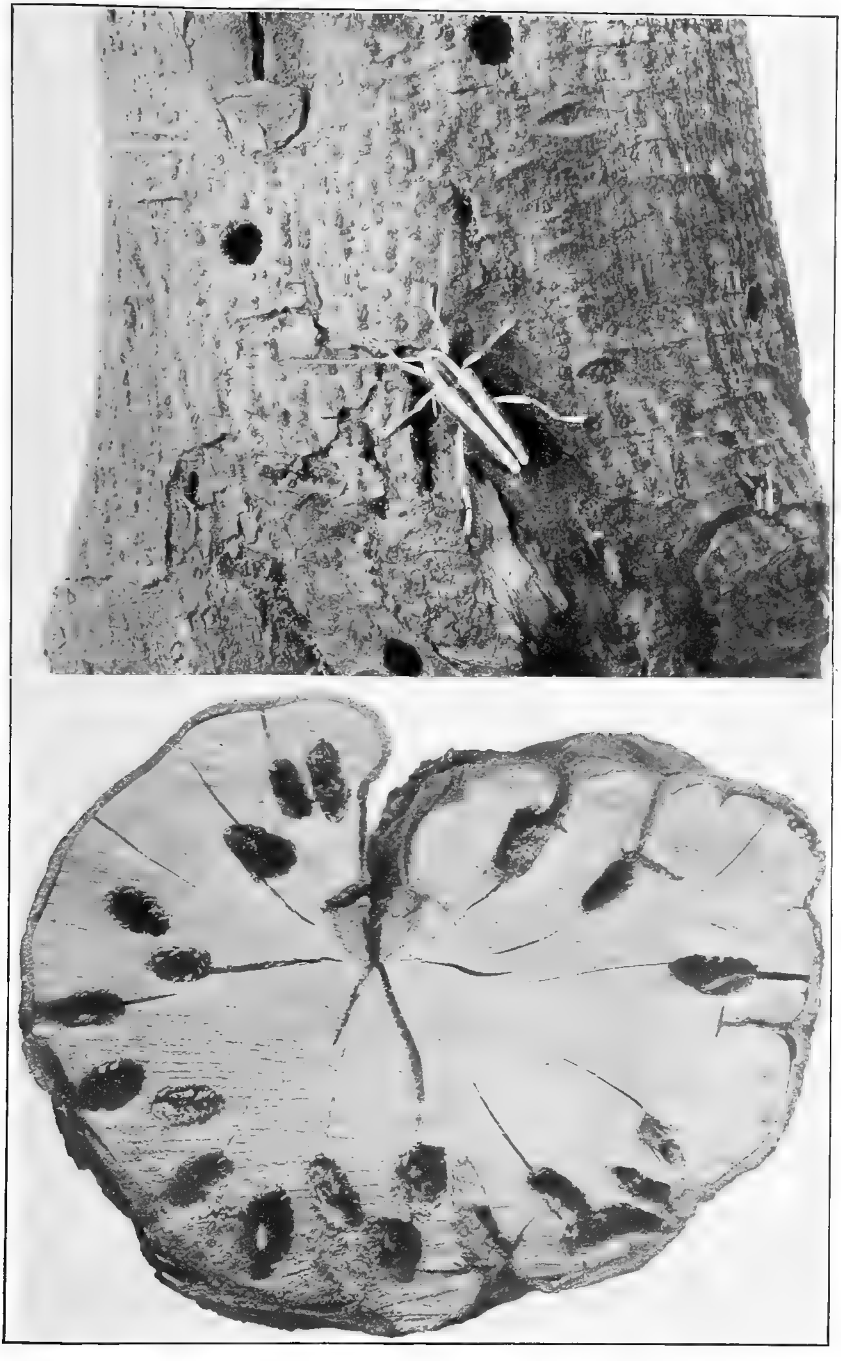
c.—Cocoon. Natural size.



d.—Adult. Natural size.

HICKORY TUSSOCK MOTH. COCOON AND CATERPILLARS.

PLATE XVI.



THE ROUND-HEADED APPLE BORER AND ITS WORK. ALL NATURAL SIZE.

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EIGHTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

CONNECTICUT

FOR THE YEAR 1908

BY

W. E. BRITTON, PH.D.

State Entomologist

New Haven, Conn.
1909

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ILLUSTRATIONS.

Figure 9 is from a drawing by W. E. Britton; 10, 19 and 20 are from drawings by B. H. Walden; 11 to 18 are from the Bureau of Entomology, U. S. Department of Agriculture.

Plates XLII and XLIII are from photographs by G. H. Hollister; LI, LIV a and b, LV a and e, and LVII b, by W. E. Britton; LVI after Prof. J. B. Smith, N. J. Agricultural Experiment Station; all others from photographs by B. H. Walden.

PART XI.

EIGHTH REPORT
OF THE
STATE ENTOMOLOGIST OF CONNECTICUT

To the Director and Board of Control of the Connecticut Agricultural Experiment Station:

I hereby transmit my eighth annual report as state entomologist of Connecticut in compliance with the statutes. The financial statements cover the two fiscal years ending September 30th, 1908, but other administrative details are for the calendar years of 1907 and 1908.

Respectfully submitted,

W. E. Britton,
State Entomologist.

REPORT OF THE RECEIPTS AND EXPENDITURES OF THE STATE ENTOMOLOGIST FROM OCTOBER 1st, 1906, TO SEPTEMBER 30th, 1908.

FOR THE YEAR ENDING SEPTEMBER 30th, 1907.

Insect Pest Account.

RECEIPTS.

From E. H. Jenkins, Treasurer	$3,750.00
Account of 1906, balance	18.53
Conn. Board of Agriculture, for gypsy moth work	100.00
	$3,868.53

EXPENDITURES.

For field, office and laboratory assistance	$1,330.85	
Printing and illustrations	83.35	
Postage	56.40	

Stationery	$1.25	
Telegraph and telephone	5.65	
Express, freight and cartage	20.75	
Library	104.84	
Laboratory apparatus and supplies	86.06	
Office supplies	28.58	
Traveling expenses	268.66	
Gypsy moth control work	1,604.91	
Balance, cash on hand	277.23	
		$3,868.53

Gypsy Moth Control Account.

RECEIPTS.

From E. H. Jenkins, Treasurer	$2,500.00

EXPENDITURES.

For salary of superintendent, and labor	$2.210.43	
Printing	12.50	
Tools and supplies	232.54	
Express, freight and cartage	11.95	
Traveling expenses	29.66	
Balance, cash on hand	2.92	
		$2,500.00

FOR THE YEAR ENDING SEPTEMBER 30TH, 1908.

Insect Pest Account.

RECEIPTS.

From E. H. Jenkins, Treasurer	$3,000.00
" " " (expenses transferred to station account)	5.25
Account of 1907, balance	277.23
Sale of cabbages (experimental plot)	5.00
Sale of postage stamps	.19
	$3,287.67

EXPENDITURES.

For field, office and laboratory assistance	$1,738.18	
Printing and illustrations	162.03	
Postage	6.64	
Stationery	7.70	
Telephone and telegraph	2.30	
Express, freight and cartage	16.25	
Library	155.86	
Laboratory apparatus and supplies	76.94	
Office supplies	23.80	
Traveling expenses	318.50	
Balance cash on hand	779.47	
		$3,287.67

Gypsy Moth Control Account.

RECEIPTS.

From E. H. Jenkins; Treasurer		$2,500.00
Account of 1907, balance		2.92
		$2,502.92

EXPENDITURES.

For salary of superintendent, and labor	$2,105.61	
Printing	2.75	
Tools and supplies	203.71	
Rental	56.00	
Express, freight and cartage	5.37	
Traveling expenses	126.26	
Balance, cash on hand	3.22	
		$2,502.92

Memorandum:—This account of the state entomologist has been duly audited by the State Auditors of Public Accounts.

OFFICE FORCE AND FIELD ORGANIZATION.

Throughout the two years covered by this report the state entomologist has been assisted by Mr. B. H. Walden as general assistant, who has had charge of the office in the absence of the entomologist; by Mr. G. H. Hollister, who has had charge of the field work of suppressing the gypsy moth; by Miss E. B. Whittlesey, who has been employed as stenographer and clerical assistant in the office. Messrs. Walden and Hollister have each year helped in the inspection of nurseries, and Mr. S. P. Hollister also assisted in this work for a few days during 1908. Miss Beatrice Ross was employed for two weeks on extra clerical work in January, 1908. All of these assistants have served faithfully and willingly, and they have contributed in no small measure to the success of the work of this office.

In the gypsy moth work at Stonington, Mr. Hollister has employed chiefly local help, and has been given full authority to hire or discharge anyone according to his judgment. About twenty men were kept at work cutting brush and turning bands during June and July, 1907, but in 1908 most of the brush had been cut and less than ten men were employed.

LECTURES, CORRESPONDENCE AND INSPECTION WORK.

During the calendar year of 1908, thirteen lectures have been given before granges and agricultural and scientific meetings, and

1,236 letters and 51 packages sent out on business pertaining to the work of the office. The force has also made forty-two inspections of nurseries, and forty-two certificates have been granted. Examinations have been made of forty orchards, gardens, etc., and one hundred and forty-seven samples of insects have been received for identification.

COLLECTION AND EQUIPMENT.

The collection of insects has been considerably increased during the past two years by exchanges and material collected within the state. Mention should here be made and thanks expressed to Mr. Charles R. Ely of Washington, D. C., who has enriched our collection with material collected at East River, Conn., supplying us with over sixty species, many of which were not in our collection, while some of them had not been recorded from the state. Also to Mr. F. A. Merrick of New Brighton, Pa., who supplied about one hundred and forty-seven species, one hundred and fifteen of which were new to the collection; Mr. C. A. Frost, of South Framingham, Mass., forty-eight species, forty-two of which were new to the collection; A. C. Samson of Boston, Mass., thirty-five species, fourteen new to the collection. Exchanges were effected with these persons, but in each case the station collection benefited by receiving many more species and specimens than we were able to give in return, the collectors expressing a desire to place their duplicates where they would be of use even though they did not receive specimen for specimen in return. This attitude is or should be the proper one for the scientist. Last but not least, thanks are due to Professor H. W. Foote of Yale University, who has for three seasons collected moths during July and August at Pemaquid Point, Me., and given them to the station collection.

The Lepidoptera (butterflies and moths) have now all been transferred to larger Schmitt boxes (11½ x 16 in. inside), which were made to order of the proper size to fill the space occupied by two ordinary boxes with the partition between them. Fifty-six of these boxes are now filled with butterflies and moths. Fourteen metal cases and several wooden cases are used to hold the collection, which now contains about 4,000 named species and over 26,000 specimens.

A colony of bees in a Cary hive has been procured for study; these swarmed in June, and the swarm was placed in a Danzenbaker hive, so there are now two hives. A Miller observation hive has also been purchased for the laboratory and is of much interest to visitors.

PUBLICATIONS FROM THE ENTOMOLOGICAL DEPARTMENT 1907-1908.

Sixth Report of the State Entomologist (Part IV of the Station Report for 1906); 88 pages, 1 map, 13 text figures, XVI plates. 9,000 copies, distributed in March, 1907.

Seventh Report of the State Entomologist (Part V of the Station Biennial Report for 1907-1908); 73 pages, 6 text figures, XVI plates. 9,000 copies, distributed in March, 1908.

Bulletin 155. The Elm Leaf Beetle, by W. E. Britton. 15 pages, 6 figures. 10,000 copies. May, 1907.

Bulletin of Immediate Information No. 5. The Gypsy Moth Situation and the New Law. 4 pages. 1,000 copies. June, 1907.

Bulletin 157. Lead Arsenate and Paris Green. Part II. Directions for Their Use as Insecticides, by W. E. Britton. 12-13 pages. 10,000 copies. September, 1907.

Bulletin 159. Spray Calendar. Insect portion by W. E. Britton. 12,000 copies. January, 1908.

Occurrence of the Gypsy Moth in Connecticut, by W. E. Britton. A short paper read at the meeting of the Association of Economic Entomologists at New York, December, 1906. Published in Bulletin 67, Bureau of Entomology, U. S. Dept. of Agr., p. 22. 4 pages. 1907.

The Gypsy Moth in Connecticut, by W. E. Britton. Report of Connecticut Board of Agriculture for 1906. 13 pages, 5 text figures. 1907.

Some Connecticut Problems, by W. E. Britton. Proceedings New York State Fruit Growers' Association for 1907, p. 151. 1907.

Report of Committee on Injurious Insects, by W. E. Britton, Chairman. Report Connecticut Pomological Society, Vol. IX, p. 28. 1907.

Do. Vol. X, p. 23. 1908.

Some New or Little-Known Aleyrodidæ from Connecticut, by W. E. Britton. III. *Entomological News,* Vol. XVIII, p. 337. 6 pages, 2 plates. October, 1907.

Tests of Various Gases for Fumigating Nursery Trees, by W. E. Britton. *Journal of Economic Entomology,* Vol. I, p. 110. 3 pages. April, 1908.

Postal Card Bulletin on Canker Worms, by W. E. Britton. 5,000 copies. October, 1908.

Notes from Connecticut, by W. E. Britton. *Journal of Economic Entomology,* Vol. I, p. 313. October, 1908.

Notes on a New Sawfly (*Pamphilius persicum* MacG.) Attacking the Peach, by B. H. Walden. Bulletin 67, Bureau of Entomology, U. S. Dept. of Agr., p. 85. 2 pages, 1 plate. 1907.

The Peach Sawfly; A Correction, by B. H. Walden. *Journal of Economic Entomology,* Vol. I, p. 160. April, 1908.

CHIEF LINES OF WORK.

The general work of suppressing the gypsy moth, inspecting the nurseries, identifying insects and correspondence has consumed the usual amount of time and effort. Each of these is mentioned on another page of this report.

A study has been made of the insects attacking truck crops, and in this work tests have been made at Mount Carmel of various substances to prevent injury from the cabbage maggot. The squash borer has also been the object of similar tests.

Tests of various substances for fumigating to destroy San José scale on nursery stock have been continued, and some attention has been given to the question of preparing "soluble oils" for killing the San José scale. Further observations regarding the life history of the peach sawfly have been made by Mr. Walden, and several localities have been examined for mosquito-breeding areas.

Much time has been devoted to the insect collection and to the preparation of the papers on the Orthoptera and Hymenoptera of Connecticut which are to be published by the State Geological and Natural History Survey. The manuscript of the Orthoptera has been completed and is now awaiting publication.

ENTOMOLOGICAL FEATURES OF 1908.

From year to year the careful observer notes changes as regards the prevalence or scarcity of various kinds of insects, especially those which are pests attacking cultivated crops. The fluctuation is great with some species, such as the spiny elm caterpillar, *Euvanessa antiopa* Linn., and the apple leaf miner, *Tischeria malifoliella* Clem., which were exceedingly abundant in 1906, but have hardly been noticed since then. They are present each year, but they attract attention only when they become abundant. On the other hand, certain insects like the potato beetle, *Leptinotarsa decemlineata* Say, the cabbage butterfly, *Pontia rapæ* Linn., and the important currant worm, *Pteronus ribesii* Scop., are so constant in their appearance and numbers that the grower expects to combat them year after year, and thus makes control operations a part of his regular work and plans for it accordingly.

The winter of 1907-1908 was rather severe, and as the preceding winter was also a severe one, the San José scale in many cases was killed so that it has not spread as much as usual. The reason apparently must be due to climatic conditions rather than to any particular predaceous or parasitic enemies which are effecting its control. At least, no such enemies have been observed in Connecticut which have not been present for several years, and those have not seemed to be more abundant than usual. In some instances the pest has not made any appreciable spread in two years, and some persons believe that it is no longer to be feared as a dangerous enemy to orchards; but in other cases, especially in young orchards and in some nurseries, the San José scale has multiplied sufficiently to leave no doubt in the minds of the owners or of any observer that it still must be reckoned with as the chief insect enemy of orchards in Connecticut. There should be no "let-up" in the thoroughness or regularity of the remedial treatment.

Canker worms, as predicted, were more abundant than in 1907, and defoliated many apple orchards and shade trees. They will doubtless be even more abundant in 1909, and everyone who wishes to save the foliage of his trees should band them. A detailed account of the two species of canker worms will be found on page 777 of this report.

The elm leaf beetle was more abundant and caused more injury to shade trees throughout the state than for several years. The precipitation was below the normal, especially during June and July, and this, following a dry season in 1907, prevented the development of the white fungus that normally kills large numbers of pupæ and adults. Many of the beetles, though of course a small proportion, were killed by the spined soldier bug, *Podisus malculiventris* Say (=*spinosus* Dall.), which was more than usually abundant. The elm leaf beetle may be expected to do fully as much damage in 1909, and all trees which were defoliated during the past season should be sprayed with poison next summer.

In the vicinity of New Haven beans were attacked and injured by a green striped caterpillar, which on rearing the adults proved to be the green clover worm, *Plathypena scabra,* which has not before been reported on beans in Connecticut. An article on page 828 gives an account of this insect.

Tussock moths of all kinds were abundant, but late in August and through September many dead caterpillars were found on the trunks of trees, having been killed by a fungus, the prevalence of which has undoubtedly been an important check to these insects and will render them less common next season.

Plant lice were abundant and checked the growth of young apple trees in orchards and nurseries.

Mites (probably *Tetranychus bicolor* Banks) were abundant everywhere on chestnut, and the same or an allied species was also on oak, causing the leaves to turn brown late in the summer. The pear leaf mite, *Eriophyes pyri* Nal., was prevalent, and specimens were received from several localities, where it formed reddish galls upon the leaves.

NURSERY INSPECTION.

The annual inspection of nurseries, as provided for by the General Statutes (Sections 4388-4389), was begun this year on August 27th, or about a week earlier than usual. Fair weather prevailed and enabled us to nearly complete the work by the middle of October, though not wholly finished until November.

The condition of the nurseries of the state was on the whole found to be somewhat better than last year, but there is no decided change. Individual nurseries presented differences, some being better and some worse. In a region thoroughly infested with San José scale, where nurserymen have carefully sprayed their growing stock with soluble or miscible oil, one part in not more than fifteen parts of water, the plantations have been much improved, some being comparatively free from scale. On the other hand, where this treatment was done indifferently or carelessly, or neglected altogether, the stock was in bad condition and much of it was destroyed.

The inspections were made by Messrs. Britton, Walden, G. H. Hollister and S. P. Hollister, the first three being employed throughout the work and the last helping only about ten days in the large nurseries.

Two nurseries were inspected during the spring and forty in the fall, making forty-two inspections. Forty-two certificates were granted. The death of one nurseryman and the appearance of five new firms changes slightly the list, which follows:

LIST OF NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1908.

Name of Firm.	Location.	Inspection finished.	Certificate number.
Atwater, C. W.	Collinsville	Sept. 28,	297
Barnes Bros. Nursery Co.	Yalesville	Sept. 26,	294
Beattie, Wm. H.	New Haven	Sept. 28,	295
Bowditch, J. H.	Pomfret Center	Sept. 3,	286
Brainard, D. Wm. & C. F.	Thompsonville	Oct. 19,	313
Burroughs, Thos. E.	Deep River	Oct. 12,	309
Burr & Co., C. R.	Manchester	Sept. 22,	291
Comstock & Lyon	Norwalk	Oct. 27,	317
Conine Nursery Co., The F. E.	Stratford	Sept. 29,	296
Conn. Agricultural College	Storrs	Oct. 13,	310
Conn. Agr. Experiment Station, Forest Nursery (A. F. Hawes, State Forester, New Haven)	Rainbow (Windsor)	Oct. 5,	304
Conway, W. B.	New Haven	Oct. 24,	315
Dehn & Bertolf	Greenwich	Sept. 23,	292
Dwyer, John E.	Manchester	Nov. 12,	321
East Rock Park Nursery (G. X. Amrhyn, Supt.)	New Haven	Sept. 2,	285
Elizabeth Park Nursery (G. A. Parker, Supt.)	Hartford	Nov. 5,	320
Elm City Nursery Co,	New Haven	Sept. 5,	287
Gardner's Nurseries	Cromwell	Oct. 29,	318
Gurney & Co., H. H.	New Canaan	Sept. 22,	290
Hale, J. H.	So. Glastonbury	Oct. 12,	308
Holcomb, Irving	Granby	Sept. 18,	288
Houston & Sons, J. R.	Mansfield Depot	Oct. 9,	305
Hoyt's Sons Co., Stephen	New Canaan	Sept. 22,	289
Hubbard & Co., Paul M.	Bristol	Oct. 5,	301
Hunt & Co., W. W.	Hartford	Oct. 1,	298
Kellner, H. H.	Danbury (2)	Oct. 21,	314
Kelsey & Sons, David S.	West Hartford	Sept. 29,	299
Keney Park Nursery (G. A. Parker, Supt.)	Hartford	Nov. 5,	319
Malone, Geo. W.	Highwood	Oct. 26,	316
Phelps, J. Wesson	Bolton (2)	Oct. 9,	306
Pierson, A. N.	Cromwell	Sept. 1,	284
Platt Co., The Frank S.	New Haven	Oct. 13,	311
Purinton, C. O.	Hartford	Dec. 24,	323
Ryther, O. E.	Norwich	Oct. 16,	312
Schoonman, W. J.	Danielson	Dec. 7,	322
Scott, J. W.	Hartford	Oct. 10,	307
Sierman, C. H.	Hartford	Oct. 2,	300
Vidbourne & Co., J.	Hartford	Sept. 25,	293
Woodruff, C. V.	Orange	Oct. 5,	302
Woodruff & Sons, S. D.	Orange	Oct. 5,	303

ACCOUNT OF PROGRESS IN SUPPRESSING THE GYPSY MOTH IN CONNECTICUT.

For an account of the discovery of the gypsy moth in Connecticut at Stonington and the attempts to control this pest the reader is referred to the three preceding reports of this station (1905, p. 246; 1906, p. 235, and 1907-08, p. 300). Only a record of progress is here given.

Throughout the year Mr. G. H. Hollister has been the superintendent in immediate charge of the work. Commencing on November 18th, 1907, Mr. Hollister employed about five men for most of the time during the winter, cutting and burning brush, pruning trees and scouting for egg-masses. About ten rods of stone wall had to be overhauled and relaid, a number of wood and rubbish piles had to be looked over, and, of course, the trees examined.

In May the trees were banded, about 14,000 in all, including all those within the boundaries of the infested area and many outside, especially to the north. In doing this we used one and one-half bales of eight-ounce burlap cut into eight-inch strips.

During 1908 no indications were found that the pest had spread to the region outside of the area known to be infested the previous year, but on the contrary, over a portion of this area where caterpillars were taken in 1907 none were found in 1908. The size of the area actually known to be infested has therefore been decreased by the suppression work. The Stanton place was perhaps the worst center of infestation for the season, but during June about two hundred and seventy-five caterpillars were discovered on some low rosebushes in the loose stones beside the wall near the Ross estate. A careful search was here made and all caterpillars that could be found were destroyed. The spot was then oiled and burned.

On July 2d two of the men discovered some caterpillars on weeds and brush in and around the chicken yard of Mr. Kellar's residence on Bay View Avenue. In making a systematic hunt, about one hundred and twenty-five in all were found, and the weeds and useless bushes were immediately cut and burned and the stone wall burned out with a torch of flame. Fifty gallons of oil was used in burning out walls, stoneheaps and dumps. A few caterpillars were found each day at Walnut Grove, but not in important numbers. The seriousness of this infestation lies in the character of the region, a dense grove of tall oak, hickory and other trees, which grow among rocks and boulders, making it difficult to control the pest should it once gain a foothold. Much searching was done here in addition to the regular work of examining bands. The men climbed the trees perhaps a dozen times during the summer, and in this way many of the caterpillars were found and destroyed.

All of the coniferous trees and part of the apple trees and ornamental shrubbery on the Stanton place, some shrubs of Japanese quince at Mr. Darrell's, the bushes near the water at Mr. Simmons', small fruit trees and Boston ivy at Mr. Koelb's and the quince bushes at Mrs. Thatcher's were sprayed with lead arsenate (three to five pounds in fifty gallons of water), thirty pounds of the poison being used. Mr. Hollister observed dead and dying caterpillars a few days after the applications. "Tree Tanglefoot" was applied to the trunks of the evergreens and apple trees adjoining in order to prevent the caterpillars from crawling up or down, about twelve pounds of this material being used.

Scouting for Egg-Masses.

All trees, and many of the fences, stone walls and buildings within the infested area were examined for egg-masses during the winter. A careful search was made around the places where caterpillars were taken during the preceding summer, and seventy-three egg-masses were found and destroyed by soaking them with creosote. Most of the scouting was done by Messrs. Hollister, Norman and McDermott, and before April 1st this was finished and Hollister and Norman had worked about two weeks around Hartford. Mr. Hollister had also visited several towns in the northeastern part of the state. According to agreement, Mr. Rogers furnished help to scout the infested region after it had been examined by our men, but on account of the great amount of work done in Massachusetts, Maine and New Hampshire, he could send only one man, Mr. G. D. Whitehead, who worked in Connecticut during the month of April, first going over the Stonington infested territory with Mr. Hollister (finding nine egg-masses), and then with him scouting the road to New London and then from New Haven to Hartford.

The scouting done outside of Stonington may perhaps be best described by the following notes by Mr. Hollister.

SCOUTING FOR THE GYPSY MOTH IN OTHER PARTS OF THE STATE.

Hartford Region—"An egg-mass of the gypsy moth having been found in Springfield, Mass., and Hartford being on the same route from Boston to New Haven and New York, it was thought advisable to spend some time scouting around the garages in that city, and then to scout the main highways leading to Springfield on each side of the Connecticut River.

"Scouting was commenced about the 24th of February, 1908, and continued two weeks in this vicinity by Mr. E. W. Norman and myself.

"On the west side of the river the towns of Windsor, Windsor Locks and Suffield were visited, the scouting being done along the main highway and including the shade trees, the orchards bordering on the highway, freight yards and garages. In the villages several of the streets other than the main one were scouted. On this side of the river scouting was carried on as far north as the road leading from Suffield to Thompsonville.

"East Hartford, South Windsor, East Windsor Hill, Warehouse Point, Enfield and Thompsonville were all visited, as well as all the territory between these villages along the main highway on the east side of the river. Considerable time was spent around the freight yard in East Hartford, as a great many of the cars pass through infested territory in Massachusetts.

"The scouts were on the lookout for any nests of the brown-tail moth as well as for those of the gypsy moth, but no evidences were found of either.

"It is estimated that a distance of one hundred and twenty-five miles was traversed.

Eastern Connecticut—"The latter part of March and first of April several of the larger towns were visited by the writer to look for evidences of the gypsy moth and brown-tail moth.

"Norwich, Plainfield, Danielson, Putnam, Grosvernordale, East Thompson, Willimantic and Middletown were visited. In these places, garages, freight yards, and some of the shade and fruit trees were examined.

"As Putnam is the largest town in the northeastern part of the state nearest the Massachusetts infestations, considerable time was spent there scouting the shade trees and orchards bordering on the highways. Quite a little time was occupied in scouting the village of East Thompson. At the other places above mentioned only the stations, freight yards, garages and the trees near the same were scouted. Not a sign of either the gypsy or brown-tail moth was found.

"A distance of forty miles was covered.

"Mr. G. D. Whitehead, a government scout, was sent to Stonington April 1st, and scouted in various parts of the state until May 2d. He and the writer scouted the main highway to Mystic, Noank and Midway, spending some time at the freight yard in the latter place.

"Three days were spent in New London, where the trees were examined on Main, Bank and Broad streets and on Montauk, Pequot and Ocean avenues. Several garages and the freight yards were scouted, also some of the trees along the banks of the Thames River near where automobiles attending the boat-races were stationed. The trees in Williams Park and around Williams Memorial Institute were scouted.

"About thirty-five or forty miles were traversed, and no evidence of moths were found.

New Haven to Hartford—"Mr. Whitehead and the writer left for New Haven the 23d of April, where they began scouting for the gypsy moth. Twenty-six garages were visited and the trees in the vicinity of the same were inspected. The freight yards were also examined.

"Scouting was then taken up along the main automobile route to Hartford, passing through the towns of North Haven, Wallingford, Yalesville, Meriden, Berlin Junction, New Britain and Newington to Hartford. Here, as on the other trips, the shade trees and orchards bordering on the highway were scouted, also the garages in Wallingford, Meriden and New Britain.

"New Britain Avenue and Farmington Avenue in Hartford were both scouted, as automobiles follow both routes into the city.

"No evidences of the gypsy moth or brown-tail moth were found after traversing a distance estimated at eighty miles.

"About a week was spent on this route, and then May 2d was spent scouting about in the village of Pomfret. This included the street trees and also the shade trees near Pomfret School. The street leading from the station past the school to the Putnam road was scouted, also another leading from the station out to some private estates a mile away.

"Here, as at the other places, no moths were found."

FUNDS.

The State Board of Control has seen fit to grant the funds necessary to carry on the work, $2,500 having been used during the fiscal year ending September 30th, 1908. It is hoped that the legislature will renew the provisions of the act, or at least provide funds to continue the suppression work until the pest has been exterminated from the state.

INFESTED LOCALITIES NEAR CONNECTICUT.

During the year the Massachusetts authorities sent scouts to examine the main thoroughfares in various portions of that state, and this resulted in finding gypsy moth infestations in several new places, including Springfield, Greenfield, Palmer and Warren. Springfield being only a few miles from the Connecticut border, the fact that egg-masses were found there naturally caused some anxiety lest the whole region be infested, but a careful search of both sides of the river from the state line southward did not result in finding any signs of the pest.

The edge of the general infestation in Eastern Massachusetts, however, has been extended from year to year by the natural spread of the insect, aided by the usual methods of conveyance and traffic, until it now reaches well towards the boundary of Connecticut.

PRESENT CONDITION OF THE INFESTED AREA AT STONINGTON.

The conditions are now more favorable for the extermination of the gypsy moth than they have been at any time since this pest was discovered to be in the state. The territory has been well cleaned up by cutting brush and disposing of rubbish, by pruning and scraping trees and cutting worthless ones, and filling and tinning cavities. The actual size of the infested area has been considerably reduced during the year, so that it will not be necessary to band as many trees next year. This will require a smaller force of help, and of course will be less expensive.

GENERAL SUMMARY.

	1906	1907	1908
Egg-masses laid during preceding year, number destroyed	29	118	73
Egg-masses laid during same year, number destroyed	47	70	3
Caterpillars, number destroyed	10,000	2,936	2,560
Pupæ, number destroyed	47	200	44
Trees banded with burlap, number of	1,300	13,000	14,000
Funds expended by the state	$1,500	$4,550	$2,500
" " " " government	....	272	77

CANKER WORMS.

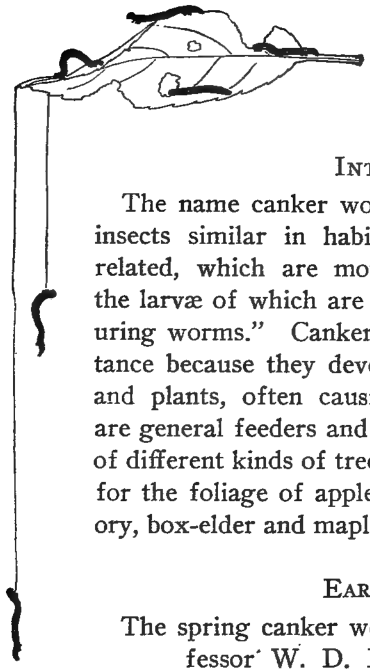

FIG. 9. Canker Worms on apple leaf. Reduced.

Spring Canker Worm,
Paleacrita vernata Peck.
Fall Canker Worm,
Alsophila pometaria Harris.

INTRODUCTION.

The name canker worm is applied to two species of insects similar in habits and appearance and closely related, which are moths of the family Geometridæ, the larvæ of which are known as "loopers" or "measuring worms." Canker worms are of economic importance because they devour the foliage of various trees and plants, often causing considerable injury. They are general feeders and therefore attack a large number of different kinds of trees, but seem to have a preference for the foliage of apple, elm, chestnut, pear, oak, hickory, box-elder and maple, in about the order named.

EARLY RECORDS.

The spring canker worm was first described by Professor W. D. Peck in 1795. The difference between the sexes was known at this time, but there was supposed to be only one species, evidently *vernata*. The following is a quotation from Peck's original account as published by Ridley.*

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* Seventh Annual Report on the Noxious, Beneficial and Other Insects of Missouri, 1874, p. 89.

"These insects (the Canker-worm) appear in the spring earlier than any other of the moth tribe—about the middle of March. Their rise, however, from the earth will be delayed or hastened according to the temperature of the atmosphere and state of the soil. They are found under a double form, the males being furnished with, and the females being destitute of, wings. This circumstance necessitates the females to ascend the tree by its trunk in order to deposit their eggs upon the branches. The males by their wings resort to them, and are found in the evenings hovering around the trees. In three or four days after they begin to rise, they are found *sub-copula.* This office is performed in eleven or twelve days after their first appearance. The males die and disappear. In thirteen days the females deposit their eggs. These they place in the crannies of the bark in the forks of small branches; and where there are spots of moss upon the smaller limbs, they seem most fond of insinuating themselves into the cavities between its leaves. For this purpose the females are furnished with a tube through which the egg is passed, with which she investigates the apertures in the bark or moss and ascertains their depth. * * * Each female lays at a medium an hundred eggs. The ultimate purpose of their being thus performed, they die."

Dr. T. W. Harris of Cambridge, Mass., made observations on canker worms of that section, which he supposed to be Peck's species, though somewhat larger and differently marked. He states:* "Perhaps they constitute a different species from that of the true canker worm moth. Should this be the case, the latter may be called *Anisopteryx pometaria.*"

The spring canker worm was the common species in the Mississippi River valley, while the fall species is more common in New England, though both species are found throughout the eastern portion of the United States. Dr. Charles V. Riley was probably the first to accurately describe† and figure the characters of both kinds of canker worms, thus proving them to be distinct species.

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* Insects Injurious to Vegetation, 1841, p. 333. Flint Edition, 1863, p. 402.

† Seventh Annual Report on the Noxious, Beneficial and Other Insects of Missouri, 1874, p. 80.

HISTORY IN CONNECTICUT.

Mr. Henry T. Blake of New Haven states* that "in 1839, by vote of the Common Council, one hundred and fifty maples and elms, principally maples, were set out on the public square. The maples were preferred at that time on account of the liability of elms to be ravaged by the measuring worm, or canker worm, as it was generally called. This worm has appeared at intervals since 1750, but the first serious experience of them within the present century occurred in 1838. Other visitations followed at frequent intervals down to 1850 and later, though in a modified degree. Prior to 1846 for several years before the middle of June the trees on the Green were stripped as bare as in the depths of winter. The fence, which was of wood, painted white, was so covered with worms as to appear entirely black. The walks were literally carpeted with them, and the air was full of their squirming forms descending from the barren branches. Many schemes were proposed for their extermination, but none were successful until the plan was adopted of surrounding the trunk of every tree in the fall of the year with large tin troughs filled with oil. This device was used quite generally, but the troughs were expensive and the oil was blown by the wind over the sidewalks and the clothes of passers-by. A smaller trough was then used, made of sheet lead, and these were placed upon the elms almost universally throughout the city, being kept in order and supplied with oil by annual contract. These remedies, continuously applied for several years, greatly diminished the pest, and of late the last of the lead troughs have disappeared. A band of cloth or paper coated with tar or printers' ink is now regarded as a sufficient protection."

According to Dr. Joseph Barratt, canker worms had disappeared in 1846,† and we have the statement of Mr. Robinson that they were again troublesome in 1866.‡ From what we know of the periodical occurrence of this pest, it is quite probable that an outbreak intervened, though we do not have a record of it. In 1884, Mr. P. M. Augur, then pomologist of the Board of Agriculture, reported* that canker worms were abundant in some localities during the season and caused considerable damage.

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* Chronicles of New Haven Green, 1898, p. 30.
† Transactions Conn. Agr. Society for 1854, p. 120.
‡ Report Conn. Board of Agriculture for 1866, p. 81.

Again in 1896, canker worms were abundant in the southern part of the state, and the writer published a short article† giving a brief description of the two species and recommending treatment. The fall canker worm was the more prevalent, and was responsible for most of the injury about the station grounds, though the spring species was present in apple orchards of the state.

From 1896, canker worms were present and caused damage to trees until 1900, when they became scarce at the station, so that it was difficult to find specimens. Their absence continued until the autumn of 1907, when adult males were noticed to be quite numerous, and early in the summer of 1908 orchard and shade trees in the southern part of the state were ravaged. During the season this office received four samples of canker worms and twenty-three letters regarding their work. The elm trees of New Haven were attacked and the leaves generally eaten, but most people attributed the injury wholly to the elm leaf beetle, which was also present in serious numbers. Canker worms even attacked privet hedges in some localities and defoliated portions of them. Though none of the trees on the station grounds were sprayed, the damage was sufficient to warrant the expense of banding the trees, and this was done in October.

A postal card bulletin was issued by this station, about October 1st, calling attention to the prevalence and injury of the canker worm and giving information about applying the sticky bands.

LIFE HISTORY.

The adults of the fall species appear during the warm days of November and December, often occurring in great numbers on foggy days during a thaw after the ground has been frozen. In 1908, the first females were observed around the bands October 28th, and from that time on they increased in abundance, being more in evidence than the males up to November 20th, when the males were apparently much in preponderance. Many eggs were laid on the trees before the middle of November, and only a few males could be found. The females of both species are without wings, and must necessarily crawl up the trunks of the trees to lay their eggs on the twigs. Males, on the other hand, are provided with wings, and fly short distances at night and even during dark cloudy days. Many of the adults, however, do not emerge until March, and this is especially the case when the ground freezes early in the fall and does not thaw out until late in the winter.

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* Report Conn. Board of Agriculture for 1884, p. 290.

† Report Conn. Agr. Expt. Station for 1896, p. 234.

In Saybrook, where the elm trees were considerably damaged by canker worms in 1907, sticky bands were applied about March 1st, 1908, as it was supposed to be the spring species that caused the injury; but it was found later that the fall species was the more abundant and that enough eggs had already been laid before the application of the sticky bands so that the trees were quite badly eaten by canker worms.

The eggs, though deposited in late fall or in early spring, hatch in Connecticut during the last of April or the first few days of May.

The young larvæ are at first very small, and they soon begin to feed on the tender unfolding leaves. They eat holes entirely through the leaves, or in fact devour all of the green tissue, leaving nothing but the veins. Later, as the foliage becomes firmer and more leathery, they often leave the greater portion of the network, especially in case of the apple (shown on Plate XLV) which turns brown in June and looks as if a fire had gone through the orchard.

The caterpillars feed from four to five weeks, during which time they spin down on threads of silk when disturbed, and molt three times. They then go to the ground and transform to the pupa or chrysalid stage. By June 6th, 1908, all canker worms had gone into the ground to pupate. They then remain in the pupa stage until the late fall, when the adults of the fall canker worm begin to emerge in November, and during warm days for two months they may be seen clustering on the trunks of trees; but some do not appear until March and April, at the same time that the spring species comes forth. There is but one generation each year.

Canker worms are always rather local in their attacks, and the writer has often seen large orchards defoliated in certain localities, while in adjoining towns no damage could be seen. During 1908, the most severe injury occurred near the coast, though the insect was present locally in the northern portions of the state.

Description.

Spring Canker Worm, *Paleacrita vernata* Peck.

Egg. Laid in irregular masses which, according to Quaintance,* contain from seventeen to one hundred and nineteen eggs, with an average of forty-seven. Usually in secreted places in the crevices of the bark. The shell is thin, delicate, and of a light brown color, but more or less iridescent. About 0.7 mm. in length, and two-thirds as broad as long. See Plate XLIV b.

Larva or *Caterpillar.* The larva or caterpillar is slender, about three-fourths of an inch long when full grown, and is longitudinally striped with fine pale lines. The general color is dark gray or brownish. The most distinguishing feature, however, is that *no pro-legs are borne on the eighth segment,* there being in all only two pairs of pro-legs. The head is distinctly mottled and spotted.

Pupa or *Chrysalis.* Pupa light brown, about 7 mm. in length, enclosed in a simple earthen cell lined with a few threads of silk. The cell can be easily broken. The pupa is somewhat pitted, the wing sheaths of the male extending to the sixth abdominal segment, while those of the female extend only to the rear edge of the fifth segment. The male pupa is tipped with a spine, which is generally simple. See Plate XLIX a.

Imago or *Adult Moth.*

Male. Wing expanse of from seven-eighths to one and one-fourth inches, antennæ with less than forty joints, the longest more than twice as long as wide. Palpi short, two-jointed. Wings brownish gray, semitransparent, the fore wings marked rather indistinctly with three dark lines. A short dark line also bisects the apical angle of the fore wing. There is no prominent white spot on the costal margin. The rear wings are somewhat lighter and are without markings. Shown on Plate XLVII a.

Female. Antennæ with thirty or more joints, the longest about three times as long as wide. Antennæ, legs and body pubescent, usually with brown and white or gray scales. A black or dark brown stripe extends longitudinally along the back. Abdomen tapering and terminating in a two-jointed ovipositor, which can be exserted and is rather conspicuous. Wingless.

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* Bulletin 68, Bur. of Entomology, U. S. Dept. of Agriculture, p. 18.

Fall Canker Worm, *Alsophila pometaria* Harris.

Egg. Shaped like a truncated cone, fastened endwise to the tree or object, with the thicker end outward and marked with a dark spot in the center and a dark circle near the margin. The eggs are deposited in rows, in compact clusters of between fifty and three hundred eggs each (averaging about one hundred), and are usually laid on the bark of the smaller branches, but may be found on the trunk, or even on fences or stones. When sticky bands are employed, the eggs are laid sometimes on the band itself or on the bark of the trunk just below the band. In color the eggs are brownish gray, but somewhat darker than those of the spring species. On hatching, the young larvæ emerge from the outer end of the eggs, leaving a round hole about the size of the circular ring. Egg-masses are shown on Plate XLIV.

Larva or Caterpillar. Pale olive green at first, with pale head; later a dark gray or brownish form is often found together with the light green caterpillars, both of which are similarly striped with whitish lines. Both forms emerge from the same mass of eggs. *A pair of pro-legs is borne on the eighth segment,* making in all three pairs of pro-legs. The head is dark and indistinctly spotted. About three-fourths or seven-eighths of an inch long when fully grown. Caterpillars are shown on various food plants on Plates XLV and XLVI.

Pupa or *Chrysalis.* Somewhat stouter or broader and darker brown than in the spring species. Male wing-sheaths reaching to the sixth abdominal segment. Apex more blunt than in *vernata,* and the spine decurved and *always forked.* About 7 mm. in length. Not pitted. Enclosed in a rather strong silken cocoon interwoven with particles of soil, making a cell that is not easily crushed. See Plate XLIX b.

Imago or *Adult Moth.*

Male. Wing expanse of from one to one and one-fourth inches. Brownish gray in color, with a slight purplish reflection. Antennæ with over fifty joints, the length of the longest being less than twice the diameter. Palpal joints indistinguishable. The wings are firmer, less transparent and darker in color than in the spring species. The fore wings are crossed by two whitish bands, the distal one being offset inward on the front margin, where it forms a prominent spot known as the costal spot. This outer band continues, though less conspicuous, across the rear wings. The inner band is much less prominent, or obsolete, and does not appear on the rear wings. Males are shown on Plate XLVII b.

Female. Antennæ with over fifty joints, the longest about as broad as long, not pubescent. Body and legs uniform ash-gray in color, without markings. Wingless. Abdomen without visible ovipositor. A female and egg-mass are shown on Plate XLIV a.

Number of Eggs Laid by the Fall Canker Worm.

On an average the female lays about one hundred eggs, usually in a single cluster, though sometimes in two clusters or in small scattered lots. The following figures show the number of eggs in isolated clusters collected from trees from which actual counts were made:

140	41	68	115	100
215	130	41	109	97
47	146	99	59	61
36	95	97	57	57
258	130	64	52	194
94	51	122	110	96
105	89	58	101	55
87	100	87	59	76
86	55	141	108	115
43	38	71	111	69
59	75	78	140	59
72	80	193	124	109
122	111	91	96	54
55	148	54	93	77
209	56	62	143	50
204	72	100	102	88
58	57	47	131	43
41	110	54	106	59
129	77	128	123	108
40	85	113	113	189
2,100	1,746	1,768	2,052	1,756

The above numbers of eggs in one hundred egg-masses show an average of about ninety-four eggs to the cluster and vary from thirty-eight to two hundred and fifty-eight. The smallest egg-masses probably each represent one of two clusters of eggs laid by one insect, or possibly the female was devoured by a bird or some other natural enemy before she had finished depositing eggs.

Eggs laid by females in captivity show a larger number in each mass than those collected from trees. The following numbers of eggs were laid by females collected November 20th, 1908:

165	81	140	92	206
111	90	78	89	251
114	149	95	96	231
256	126	148	128	292
148	160	108	145	242
133	173	38	112	256
240	132	102	162	191
285	102	103	109	229
135	109	146	104	181
154	157	230	51	
68	207	111	130	
202	102	233	99	
147	104	191	128	
141	114	118	148	
2,299	1,806	1,841	1,593	2,079

Thus these sixty-five egg-masses laid in confinement show an average of one hundred and forty-eight eggs, the smallest containing thirty-eight and the largest two hundred and ninety-two, while those collected from the trees out-of-doors average ninety-four each. It is hard to account for this difference. Still more curious is the fact that the numbers given in the first four columns represent eggs laid by females taken *in coitu,* and average one hundred and thirty-four to the cluster, while those in the last column were laid by females collected at random on the trees. It is not known whether these were impregnated or not, but the large average of two hundred and thirty-one to the cluster is difficult to explain. From a lot containing forty-three females, two laid no eggs and five laid eggs in irregular masses. A lot of fifty-four females had forty-two that deposited a single egg-mass each, eleven that laid two egg-masses, and one that laid three egg-masses.

NATURAL ENEMIES.

Apparently canker worms are not as highly parasitized as some other species of injurious insects, and little space is given in literature to natural enemies. Dr. Riley mentions* a mite, *Nothrus ovivorus* Pack., which Professor A. S. Packard observed feeding upon the eggs; a four-winged fly of the genus *Microgaster,* which parasitizes the caterpillars; a species of *Platygaster* that is a parasite of canker worm eggs; two large ground beetles, *Calosoma scrutator* and *Calosoma calidum,* which devour the caterpillars, and the potter wasp, *Eumenes fraternus,* which provisions its cells with the caterpillars. Mr. Robert Brown of Yale University has reared a small hymenopterous parasite from the eggs of the fall canker worm in New Haven, but at the time of this writing could not furnish any specimens and the insect remains unidentified.

In the manuscript of the "Hymenoptera of Connecticut," by Mr. Henry L. Viereck, *Ichneumon utilis* Cress. is stated to be a parasite of canker worms.

Many birds feed upon canker worms, the most important being the chickadee, bluebird, shrike, robin, creeper, thrush, cuckoo, warblers and woodpeckers.

REMEDIES.

Early Recommendations.

As the sex-differences were early known, so were the habits. Remedial treatment was also advocated in the eighteenth century, according to Dr. Samuel Deane, who wrote as follows:†

"This worm is produced from the eggs of an earth-colored bug, which having continued under ground during winter, passes up on the bodies of apple trees early in the spring. They are hatched as early as the end of May, and are so voracious that in a few weeks they destroy all of the leaves of a tree, prevent its bearing for that year, and the next, and give it the appearance of its having been burnt. As the perspiration of trees is stopped by the loss of their leaves, they sicken and die, in a few years.

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* Second Annual Report on the Noxious, Beneficial and Other Insects of Missouri, 1870, p. 102.

† The Newengland Farmer or Georgical Dictionary, 1797.

"The worms let themselves down by threads in quest of prey, like spiders; by means of which the wind blows them from tree to tree; so that in a close orchard not one tree will escape them. But trees which stand singly are seldomer infested with these insects. As they are the most pernicious kind of insects with which Newengland is now infested, if any person could invent some easy, cheap, and effectual method of subduing them, he would merit the thanks of the publick, and more especially of every owner of an orchard.

"Several methods have been tried, with some degree of success: 1. Tarring. A strip of canvas or linen is put round the body of a tree, before the ground is open in the spring, and well smeared with tar. The females, in attempting to pass over it, stick fast and perish. But unless tarring be renewed every day, it will become hard, and permit the insects to pass safely over it. And renewing the tar in season is too apt to be neglected, through hurry of business and forgetfulness. If birdlime were to be had, it might answer the purpose better, as its tenacity will continue for some time. 2. Some tie straw round the bodies of the trees. This serves to entangle and retard the insects, and prevents the ascent of many of them. But they are so amazingly prolifick, that if ever so few of them get up, a tree is greatly damaged, at least for an ensuing season or two.

"The pasturing of swine in an orchard, where it can conveniently be done, I suppose to be an excellent method. With their snouts and their feet, they will destroy many of the insects, before they come out of the ground, or while they are coming out. And I have never known any orchard, constantly used as a hog pasture, wholly destroyed, or even made wholly unfruitful by these worms. But this method cannot always be taken; and if it could, I do not suppose it would be quite effectual. When the trees are young, the swine will be apt to injure them by tearing the bark.

"There are several experiments I could wish to have tried for subduing these insects: Such as burning brimstone under the trees in a calm time;—or piling dry ashes, or dry loose sand, round the roots of trees in the spring;—or throwing powdered quicklime, or soot, over the trees when they are wet; or sprinkling them, about the beginning of June, with sea water, or water in which wormwood, or walnut leaves, have been boiled;—or with an infusion of elder, from which I should entertain some hope of success. The liquid may be safely applied to all the parts of a tree by a large wooden syringe, or squirt.

"I should suppose that the best time for making trial of these methods would be soon after the worms are hatched; For at that stage of their existence they are tender, and the more easily killed. Sometimes a frost happening at this season has destroyed them. This I am told was the case in some places in the year 1794."

At a meeting of the Connecticut Board of Agriculture in 1866 the following statement was made by a Mr. Robinson:*

"The canker worm is also troublesome, and the farmers in my neighborhood have suffered much from its ravages. If you go out in March, about half an hour after sundown, you will see crowds of millers rising up from the ground. These crawl up the trees and deposit their eggs, from which the worm in June is hatched. Now, the best way to get rid of the future worm is to prevent the miller from ascending the tree. My trees are all guarded with a mixture composed of equal parts of tar and urine, put in a band around the tree. It is not necessary to put the tar upon cloth, because it does not hurt the tree to apply it directly, and if spread upon a cloth, the worms can crawl underneath it. This application must be renewed every day while the millers are ascending the tree. If an examination is made the morning after this application of tar and urine, the bark of the tree will be found to be coated white with millers."

In these early days it was not known that there are two distinct species of canker worm, though it was known that some of the adults appeared in fall and others in spring, as the following quotation shows:†

"Mr. David Lyman of Middlefield remarked that his section of the state was a good region for the finer qualities of apples. He had found his apples, too, to be a profitable crop. The canker worm had been his greatest pest. Against this worm he had used tar as an application which had to be repeated every evening for a long time, say forty times. The canker worm moth comes up out of the ground in the fall as well as winter. Mr. Lyman has found this out by observation. To more effectually defend his trees from the ravages of this pest, Mr. Lyman has used the so-called 'Tree-protector,' which is designed to prevent the progress of the insect up the tree. It was a little instrument like a tent, held away from the tree by a wire, having its outer edge like an umbrella, with smooth strips of isinglass projecting from the edge; the design of which was this, that if the insects could crawl to the edge they could get no further on account of the slippery foothold they would have. But the conclusion from the application of these tree-protectors was this, that they were good for nothing, and the canker worm ascended the tree just as well after their application as before. He had tried next the experiment of ploughing his orchards. This had the effect to diminish the number of worms during one season upon his apple trees in an old orchard where the experiment was tried. The ploughing ought to be followed by an application of bonedust."

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* Report Conn. Board of Agriculture for 1866, p. 81.
† *Idem*, p. 84.

Further recommendations were also made at this meeting:*

"Professor Brewer said that the Professor of Zoölogy in the Sheffield Scientific School had been investigating the subject of the different pests of our trees, and especially the history of the canker worm, as it appears upon the elm trees about New Haven. Whether this variety of the worm is the same as that infesting the apple tree, the Professor was not certain, but in this they are alike, they strip the tree of foliage. The variety of worm infesting our elm trees attains its growth between the first and seventh of June. It is a common thing to say that they leave about the tenth of June. When they have attained their growth upon the tree, they leave and go down into the ground to go through with their second stage of development there, and as has been said, they come out of the ground in the fall. Three-fourths of our people believe that if they attempt to protect their trees against the ravages of this worm, that it is sufficient if the attempt is made in the spring. It is not so. These worms may come out during the warm days of winter, and also in the spring. The females cannot get up the trees without crawling, for they are not provided with wings.

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* Report Conn. Board of Agriculture for 1866, p. 85.

"There have been practiced different methods for the protection of our elm trees, and the cheapest and best is to cover the body of the tree two or three feet from the ground with paper smeared with printers' ink. This is better than the application of tar, for it remains sticky much longer. It does not gloss over like tar. It is the cheapest application that can be made, and has been tried with success in some parts of New Haven City. It must be put on in the fall and in the spring.

"The trees about the colleges were provided with a leaden rim surrounding the tree, fitting it like a collar, and having a hollow filled with oil between the rim and the tree. The idea was that the canker worm would tumble off in trying to climb around the shelving edge, or if he succeeded in getting around this that he would die in attempting to cross the intervening fluid. These were found not to work well.

"The best protection against these worms and other pests is to have their natural enemies flourish at the same time. There is an enemy of the canker worm, a green beetle, which has an enormous appetite, for they eat all the while. These beetles and the birds which live upon the pests of our trees are our best safeguards against the attacks of the worm.

"There is also a fly called the ichneumon fly, which attacks the eggs of the canker worm and blights them. All these enemies of the canker worm kill it, and diminish their numbers, so when it is noticed that during some seasons our trees are comparatively free from the worm, you may be sure that this decrease is owing to the fact that their natural enemies have increased in a corresponding ratio. When these enemies of the worm also die off, then you will notice that the elm trees are beginning to be laid bare again. And as one end of the scale goes up, the other end goes down."

Mr. T. S. Gold* made the statement that canker worms are abundant only on light soils, and advised as remedies fall plowing and the use of guards around the trunks treated with oil or tar, to prevent the wingless females from ascending to lay their eggs. At a similar meeting in 1881, Mr. P. M. Augur advised† spraying with a weak solution of Paris green or London purple as soon as the young leaves appear. Three years later, the same speaker recommended* these poisons at the rate of from eight to twelve ounces in a forty-gallon cask of water.

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* Report Conn. Board of Agriculture for 1866, p. 204.
† *Idem* 1881, p. 334.

In 1896, the writer advised† spraying the foliage with arsenical poisons and applying to the trunks of the trees bands of cloth, or paper covered with tar or printers' ink, to prevent the females from ascending. Later, tests of various substances were made, and it was found that printers' ink was about as satisfactory as anything that could be obtained for the price. Odds and ends of ink, consisting of various colors left over from job work, are sold under the name of "tree ink" at a lower price than that usually charged for printers' ink, and this is just as good for this purpose. It will harden, however, after a short time, and the writer found that by mixing with it a non-drying petroleum oil it could be kept longer in a viscid state. The oil could also be applied with a brush to the bands from time to time to keep them in proper condition. Pine tar and a preparation called caterpillar lime caused injury to some small trees, even when applied to a band of tarred paper. This method of banding trees was described by the writer in a paper read at the Fourteenth Annual Convention of the Association of American Agricultural Colleges and Experiment Stations at New Haven in 1900, and printed in the proceedings.‡

Since then a substance known as "tree tanglefoot" has been placed upon the market, and though this is a proprietary article, it is difficult to make anything for the price that equals it. It remains sticky for a long time and causes no injury to the tree, even though applied directly to the bark.

Modern Treatment.

We must still advise the same general lines of attack as were recommended years ago, namely, spraying the foliage with arsenical poisons and placing sticky bands around the trunks to prevent the ascent of the wingless females. Different substances can now be used for the purpose. The spraying method is advised in the apple orchard, where spraying is generally practised any-way on account of codling moth and tent caterpillar. In Bailey's experiments* in Central New York, Paris green (one pound in two hundred gallons of water) gave as good results as a mixture twice as strong, and seemed more effective than lead arsenate used in similar proportions. In spraying trees at Stonington to kill gypsy caterpillars, last summer, lead arsenate was used in the proportions of three pounds in fifty gallons of water, and this was later increased to five pounds. Some of the trees and shrubs were infested with canker worms, which were readily killed. Quaintance's experiments† also confirm this.

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* Report Conn. Board of Agriculture for 1881, p. 390.

† Report of this station for 1896, p. 235.

‡ Bulletin 99, Office of Experiment Stations, U. S. Dept. of Agriculture, p. 160.

Canker worms can be controlled by a careful and thorough spraying with lead arsenate (three pounds in fifty gallons of water), or with Paris green (one pound to fifty gallons of water, three pounds lime), but these quantities can be doubled if desired.

Where it is impracticable to spray the trees, canker worms can be controlled absolutely by sticky bands, if properly used.

How to Band the Trees.

The sticky substance may be applied directly to the bark, and this is often done in orchards and on woodland trees, but on shade trees on private places it is often desirable to remove the bands when they are no longer needed, and this can be done if the sticky material is placed upon a separate band. Tarred roofing paper answers the requirements, as it does not absorb the "tree tanglefoot" as cloth would do, and it is fairly durable. If the paper is placed around the trunk, the rough bark has many crevices through which the females can crawl. Hence the reason for using cotton batting to stop these.

First place around the trunk about six feet from the ground a strip of cotton batting (cheapest grade) about two inches wide. Then cover this with a band of single-ply tarred paper about five inches wide, fastened at the lap with three sharp-pointed tacks about three-fourths of an inch long. The paper should be drawn snugly enough to press the thick band of cotton into the crevices, but not enough to break the paper. If tacked in many places, the growth of the tree will break the paper. Of fifty-five bands applied in this manner none needed renewing for two seasons, and while many had to be replaced the third year, fully one-half of them lasted through the fourth season.

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* Bulletin 101, Cornell Expt. Station, p. 496.

† Bulletin 68, Bur. of Entomology, U. S. Dept. of Agriculture, p. 21.

"Tree tanglefoot" should then be spread upon the band, preferably the upper two thirds of its width, with a wooden paddle, leaving a smooth coating about one-eighth of an inch thick. If spread too thin it will become ineffective much sooner, and cannot be renovated by combing or scratching the surface, as is possible with a thicker coating. But the effect of the weather after a time will dry or harden the surface of the band so that it is necessary to add more "tanglefoot." Especially is this necessary where the moths are abundant and adhere to the bands in such numbers as to entirely cover the viscid surface and render it ineffective. Usually scratching or combing the surface of the "tanglefoot" every three weeks will keep it in good condition. The method of applying bands is shown on Plate XLVIII. Such a band as has just been described can be removed from the tree at any time without leaving any sign or scar, while if applied directly to the bark it will show as a disfiguring mark for many years. Moreover, so much more "tanglefoot" is necessary to fill the cracks of the bark and thus make an effective barrier that it costs about as much to apply it directly to the bark. No doubt some reader will ask or wonder why it is advised that the paper be so much wider than the cotton band. There are two reasons. In the first place, a narrow band of cotton fills the cracks just as well as a wide one and costs less. In the second place, it is unsightly to use a cotton band which shows either above or below the edges of the paper. For very large trees it is well to use a wider strip of paper, say six or seven inches, and for a very small tree four inches is ample width, but five inches is about right on the average.

In Connecticut the bands should be applied during October, as the moths appear about the first of November, and they should be kept in a viscid condition during this and the following months, and again in March, April, and the first part of May, in order to catch the spring females and the newly-hatched larvæ. A band of thick cotton batting is quite effective in preventing the ascent of the females, but this is more unsightly than the dark bands described above.

A band of wire cloth netting tacked by its upper edge so as to allow the lower margin to stand out one or two inches from the bark is also an effective barrier, but unless the eggs are destroyed below the band before hatching, the young larvæ will crawl through the meshes and up the tree.

COST OF BANDING TREES.

The sticky bands of tarred paper and cotton batting such as have been described in this paper were applied to trees on the station grounds in October. All trees, including fruit trees, were banded, nearly one hundred in number, and averaging rather small. "Tree tanglefoot" costs from twenty-four to thirty cents per pound according to the quantity purchased, and is put up in one, three and twenty pound cans. Tarred paper costs seventy-five cents per roll, cotton batting ten cents, twelve-ounce upholstery tacks ten cents per package.

On the basis of these figures the bare cost of banding the trees was a little more than ten cents per tree, of which about half was for labor and half for materials. The cost will vary, of course, with the size of the trees and the cost of materials and labor.

SUMMARY.

Canker worms have caused damage to trees in New England for more than one hundred years, according to our records, and from time to time during that period they have been injurious. Many orchard, shade and woodland trees were stripped in 1908. In the early days it was known that the females were wingless, and that they crawled up the trees to lay eggs, and tar bands were recommended as a remedy.

Though it was known that some of the adults appeared in fall and some in spring, they were at first supposed to belong to the same species, and it was not until 1874 that Dr. Riley published an accurate and detailed description of their characters, thus showing them to be distinct species.

The spring canker worm, *Paleacrita vernata* Peck, has long been destructive in the Southern and Middle Western States. The adults emerge from the ground during March and April and the females lay their whitish eggs, about fifty in number, in loose irregular clusters, usually under the edges of the rough bark. The eggs hatch early in May and the caterpillars feed upon the leaves. They are green, brown or dark gray in color, marked longitudinally with fine pale lines. They have *no pro-legs on the eighth segment.* They spin down on fine silken threads when disturbed, and become full grown about June 1st, going into the ground, making a simple earthen cell lined with a few threads of silk. The male pupa is tipped with a simple spine.

The adult male has a wing spread of about an inch and is of a brownish gray color. Wings are thin and semitransparent, with the markings rather indistinct. Female, brown or gray, with a black or dark brown stripe along the back and a two-jointed exsertile ovipositor.

The fall canker worm, *Alsophila pometaria* Harris, is far more common in New England than the spring species, though both occur. The adults appear in November and December, and the females lay dark gray eggs on the trees in compact clusters of about one hundred, arranged in rows, and each egg fastened by one end to the bark. The caterpillars hatch from the eggs early in May, and vary in color from light green to dark gray or brown, marked lengthwise with fine white lines. *A pair of pro-legs* is borne on the eighth segment. Like the spring species, they spin down on silken threads, and are about three-fourths of an inch long when full grown, about June 1st, when they go into the ground to pupate. The pupa is stouter than in the spring canker worm and the spine is curved and forked. It is enclosed in a silken cocoon interwoven with soil particles, making a strong cell.

The adult male is lightly larger than *vernata,* brownish gray in color, with a slight purplish tinge, wings are firmer, less transparent and darker gray in color. The fore wings are crossed by two whitish bands, the distal one being offset inward on the costal margin, forming a white costal spot. Female without wings, markings, or visible ovipositor, and uniform ash-gray in color.

Both kinds of canker worms devour the leaves of trees in the same way, and attack a large number of different kinds of trees. The fall species seems to be especially fond of apple orchards.

Spraying the trees with Paris green was first advised in the early eighties, while bands covered with tar and printers' ink have remained in use.

At the present time the best treatment for orchards is to spray with lead arsenate (three pounds in fifty gallons of water or

Bordeaux mixture), or with Paris green (one-half pound in fifty gallons). Shade and garden trees may be cared for by placing a band of sticky material, one of the best substances being "tree tanglefoot," about the trunk. This can be placed on the bark, or preferably a band of cotton batting should be placed around the trunk covered with a strip of tarred paper five inches wide, upon which the sticky material is placed. Banding is inexpensive and effective where the bands are properly cared for.

Where the fall canker worm is the destructive species, the bands should be applied during October, and kept in a sticky condition during November and December and again during March, April and May, in order to prevent both the adult female and the newly hatched caterpillars from ascending the trees. To control the spring canker worm, the sticky bands need be effective only during March, April and May.

FURTHER TESTS OF GASES TO DESTROY SAN JOSÉ SCALE ON NURSERY STOCK.

In the Report of this station for 1907, page 270, is an account of the value of various gases for fumigating nursery stock to destroy the San José scale. It was stated therein that the tests were preliminary and that conclusions based on them were scarcely warranted, yet that they indicated the desirability of making further tests with smaller quantities of carbon disulphide and carbon tetrachloride, and of longer fumigating periods with the former. Following along this line, therefore, the present paper deals with additional tests made during the last week of April, 1908. All trees were apple, and more or less infested with the scale, much more so than the trees used in the tests last year. This fact may in some measure explain the results, as it is probable that where trees are slightly infested a careful fumigation will often kill all of the scales, whereas with the same treatment the gas might not be able to reach and destroy every individual insect where the bark is thickly covered by them.

The work of fumigating and counting the scales was done by Mr. B. H. Walden.

The roots were in good condition, except where otherwise noted, and the buds had started but little. Portions of the trunk were cut from each of nine different trees and the scales examined, with the following result:

Alive	7	4	3	3	17	8	5	26	40 =	113
Dead	18	10	4	7	5	16	4	8	10 =	82
				Number alive = 58 per cent.						195

Ten trees were used in each test with carbon disulphide and carbon tetrachloride except in No. 6, which had nine trees. Five each were used in the acetylene tests, making in all two hundred and twenty-four trees which were fumigated. These were set in nursery rows on the station grounds, where they could be watched during the season.

CARBON DISULPHIDE.

The liquid was volatilized by putting it in iron frying pans heated to about 100° C., according to the method described in last year's report. The pans were placed on frames above the trees and near the top of the case. The fumigating was done in tin cases containing about six cubic feet. The figures in the table, as well as those in the text, are calculated for one hundred cubic feet. The quantities used, fumigation period and results, are shown in Table I. The effect upon the scales corresponds with the results of last year's tests in that ten fluid ounces or less of the liquid does not kill all of the scales unless acting during a long fumigation period. Thus in Nos. 1 and 2, ten ounces acting for one and two hours left over twenty per cent. of living scales, but in No. 5, where the same quantity was allowed to act for four hours, all were dead. In Nos. 6 and 9, five ounces did not kill all of the scales in two and four hours, but after being treated for six hours none survived.

As was the case in last year's tests, twenty or more ounces acting for one hour or longer killed all of the scales. Where thirty ounces acted for two hours, one tree (ten per cent.) failed to grow, though it started and afterward died.

Though not proven, our tests indicate that the limitations of carbon disulphide vary from a minimum of twenty fluid ounces for one hundred cubic feet with a fumigation period of one hour to a maximum of thirty fluid ounces for two hours. Less than the minimum may not kill all the scales, and more than the maximum may result in killing or injuring the trees. It should be understood that these tests apply only to apple and peach, and chiefly the former, and against the San José scale and no other insect.

CARBON TETRACHLORIDE.

This liquid was used in exactly the same way as the carbon disulphide, the same metal cases and heated frying pans being used. The quantities used, period of fumigation and results, are given in Table I. The results do not correspond very closely with those obtained in last year's tests, in that some scales survived in each case, where last year all were killed. Last year it seemed that carbon tetrachloride was a promising material, and its good qualities were mentioned in the Report. Though further trials may still prove it to be of some value as an insecticide, in the light of the 1908 tests it does not appear as promising as it did a year ago. Nevertheless, the figures are given here for what they are worth without further comment than to state that carbon disulphide, in spite of the inflammability and bad odor, seems to be more desirable for fumigating nursery trees to kill the San José scale than carbon tetrachloride.

ACETYLENE.

This was generated in a granite iron dish from crushed calcium carbide, the largest pieces being about one inch in diameter. Instead of the metal case a long wooden box was used. In Test No. 21 this box was used right side up with a tight cover, the carbide weighed out and placed in the dish, and the water poured in by means of a funnel through a hole in the cover. In the other tests the box was inverted over the trees on the ground, and the earth banked up around the edges of the box to make it tight. A small box was sunk in the ground under the middle of the long box, and this, projecting outward from one side, served as a place to introduce the materials. The opening in the small box was then quickly covered and banked with earth.

The data regarding the tests with acetylene will be found in Table I, but do not show this gas to be very effective in destroying the scale when used in the quantities and for the fumigating periods used in this experiment.

It does not appear that any of the gases that can be commonly and simply generated will supersede hydrocyanic acid gas for fumigating nursery stock.

TABLE I.—TEST OF GASES FOR FUMIGATING STOCK.

EXPERIMENTS WITH CARBON DISULPHIDE.

No. Expt.	Fluid ounces of liquid used for 100 cu. feet.	Fumigating period.	Number of Generating dishes.	Number of trees.	Effect on Scales.			Effect on Trees.	
					Alive.	Dead.	Per cent. Alive.	Alive.	Dead.
1	10 fluid oz.	1 hour	1 heated to 100°C.	10	35	138	20.2	10	0
2	10 "	2 "	1 " "	10	56	192	22.5	10	0
3	20 "	2 "	1 " "	10	0	123	00.0	10	0
4	20 "	1 "	1 " "	10	0	159	00.0	10	0
5	10 "	4 "	1 " "	10	0	112	00.0	10	0
6	5 "	4 "	1 " "	9	21	200	09.5	10	0
7	30 "	1 "	1 " "	10	0	101	00.0	10	0
8	30 "	2 "	1 " "	10	0	123	00.0	9	1*
9	5 "	2 "	1 " "	10	30	123	19.6	10	0
10	5 "	6 "	1 " "	10	0	160	00.0	10	0

EXPERIMENTS WITH CARBON TETRACHLORIDE.

11	10 fluid oz.	2 hour	1 heated to 100°C.	10	12	116	09.0	--	0
12	20 "	2 "	1 " "	10	4	172	02.2	9	1*
13	30 "	1 "	1 " "	10	28	123	18.5	10	0
14	30† "	2 "	1 " "	10	1	180	00.5	9	1
15	20 "	1 "	1 " "	10	3	111	02.6	10	0
16	5 "	2 "	1 " "	10	22	126	14.8	10	0
17	10 "	1 "	1 " "	10	29	200	12.6	10	0
18	10 "	4 "	1 " "	10	46	161	22.2	10	0
19	5 "	4 "	1 " "	10	33	175	15.8	10	0
20	5 "	6 "	1 " "	10	12	143	07.7	10	0

EXPERIMENTS WITH ACETYLENE.

21	40 oz. ‡ av.	1 hour	1 heated to 100°C.	5	14	28	33.3	5	0
22	80 "	1 "	1 " "	5	22	85	20.5	5	0
23	120 "	1 "	1 " "	5	15	74	16.8	5	0
24	80 "	2 "	1 " "	5	15	50	23.0	5	0
25	80 "	½ "	1 " "	5	24	85	22.0	5	0

* Tree started to grow, then died.

† More than one-fourth of liquid had not volatilized at end of period.

‡ Of calcium carbide.

MOSQUITO WORK IN 1908.

In April, a request was received from Dr. John B. McCook of Hartford, Surgeon of the First Regiment, Organized Militia, State of Connecticut, for a report regarding the breeding of *Anopheles* in the vicinity of the state rifle range in East Haven. Though this territory was examined in a general way in 1904, and nothing was found there, it was thought best to make another survey of the place, as plans had been made for the regiment to be in camp there for a week in July.

Mr. Walden visited the place on June 24th, and not finding any serious mosquito breeding-places, a report to this effect was sent to Dr. McCook. Afterward Dr. McCook furnished us a blue print map of the region, and Mr. Walden again visited the range in order to locate more definitely some of the pools. Thus the more important features were mapped and numbered, and explanatory notes were sent to Dr. McCook under date of August 13th. Following is Mr. Walden's report:

THE MOSQUITO BREEDING PROBLEM AT THE STATE RIFLE RANGE, EAST HAVEN, CONN.

The state rifle range at East Haven was examined June 24th and again August 12th, for mosquito breeding-places. At the first examination no mosquito larvæ were found, but on the second date both *Anopheles* and *Culex* larvæ were found in two places. In a dry season the range is fairly safe from mosquito breeding, but there are several low areas which in wet seasons would hold water long enough for mosquitoes to breed.

During the warm part of the season only about a week is required for mosquitoes to develop from the egg to the adult. Therefore, any place that will hold water for a week or more is liable to breed mosquitoes, and as *Anopheles,* the malarial mosquito, may breed in any place where other mosquitoes breed, it is important that these low areas should be drained. This is a comparatively simple problem. The Farm River, a large stream well stocked with fish, runs lengthwise of the range, and the low places can be drained by running simple open ditches to the river. On the accompanying map the necessary ditches have been indicated. Ditches eighteen inches wide and fifteen inches deep at the point farthest from the river will furnish ample drainage.

These may be made straight, or may curve to follow the natural drainage of the land, as seems best. The only requisites are that the bottom of the ditches be fairly smooth, and have enough fall so as to leave no places for the water to stand in pools. The edges should also be kept fairly clean.

Notes regarding a few details are as follows:

There is a depression ten or fifteen feet across, at the side of, and partly under, the bridge where the driveway crosses at the south end of the range. The bottom is more or less covered with rocks, between which the water stands. Water was present here June 24th, just after a long dry period. No mosquito larvæ found at this time. On August 12th larvæ of both *Anopheles* and *Culex* were present in small numbers. Filling the depression with dirt to the top of the rocks would make it safe.

A short distance north is a large brush-covered pondhole, which, though dry at the time of both examinations, would probably hold water even in a normally wet season. It will require a ditch several feet deep to drain it across the skirmish run. If this forms too much of an obstruction a tile or covered drain could be constructed.

Northeast from the building occupied by the quartermaster's department a low area extends inland from the main stream, in which is much standing water. Grass and weeds occur here, and it is more or less obstructed by fallen trees and brush. *Anopheles* larvæ were present August 12th. A wide ditch could be dug here, and the material used to fill, so as to make abrupt edges. These should be kept clean, so that the fish will be able to reach the edges.

To the north is a low area which can be easily drained.

Towards the north end of the range is an old choked ditch which should be cleaned out if there is any standing water in the vicinity.

The edges of the main stream should be kept clean from anything that would obstruct the fish, and any other places where water stands should be drained or filled as recommended above.

It would be hard to estimate the cost of eliminating all breeding-places, but to carry out the above recommendations, using simply open ditches, would probably cost less than one hundred dollars. Tile drains would of course cost much more, and are not necessary to do away with all possible mosquito breeding-places.

THE BEAVER SWAMP REGION.

Beaver Swamp, near New Haven, has long been regarded as unsanitary and as a source of malaria, even before the cause of malaria and its methods of transmission were known. In the mosquito survey made by this station in 1904,* this swamp was found to be the most prolific source of *Anopheles,* or malarial mosquitoes, about New Haven. The Board of Park Commissioners has been working for some time to have the city purchase this land on the grounds of sanitation, with the expectation that ultimately it may be used for park purposes. Thus a small area has been purchased each year for several years, until now nearly all of the land between Munson Street on the south and Willis Street on the north, extending from Fournier Street on the west to the proposed extension of Sherman Avenue on the east, is owned and controlled by the city.

In 1904 the results of our examination were made known to the Park Commission and to the health officer, and after another examination in 1908 the facts were communicated to the mayor, but so far nothing has been done by the city authorities to put this area in a sanitary condition.

The accompanying map (Figure 10), explained by the following numbered notes, shows where the more serious breeding-places are located:

No. 1. Small spring-like depression about three by five feet, containing *Culex* larvæ.

No. 2. Tested edge of main stream for fifty feet or so. Found a few *Anopheles* larvæ and many *Culex* larvæ.

No. 3. A sedgy depression about ten feet long, containing yellow pond lilies and breeding *Culex* larvæ. In a wet season a much larger area would be flooded.

No. 4. Large boggy area more or less covered with water, surrounding large pool with pond lilies growing in it. Found *Culex* larvæ in abundance.

No. 5. A large deep pool in edge of stream, with *Anopheles* larvæ along the irregular edge.

No. 6. A soggy area with more or less water covered with lily pads, sedges, cattails and bushes. Found many *Culex* and a few *Anopheles* larvæ.

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* Report of this station for 1904, p. 293.

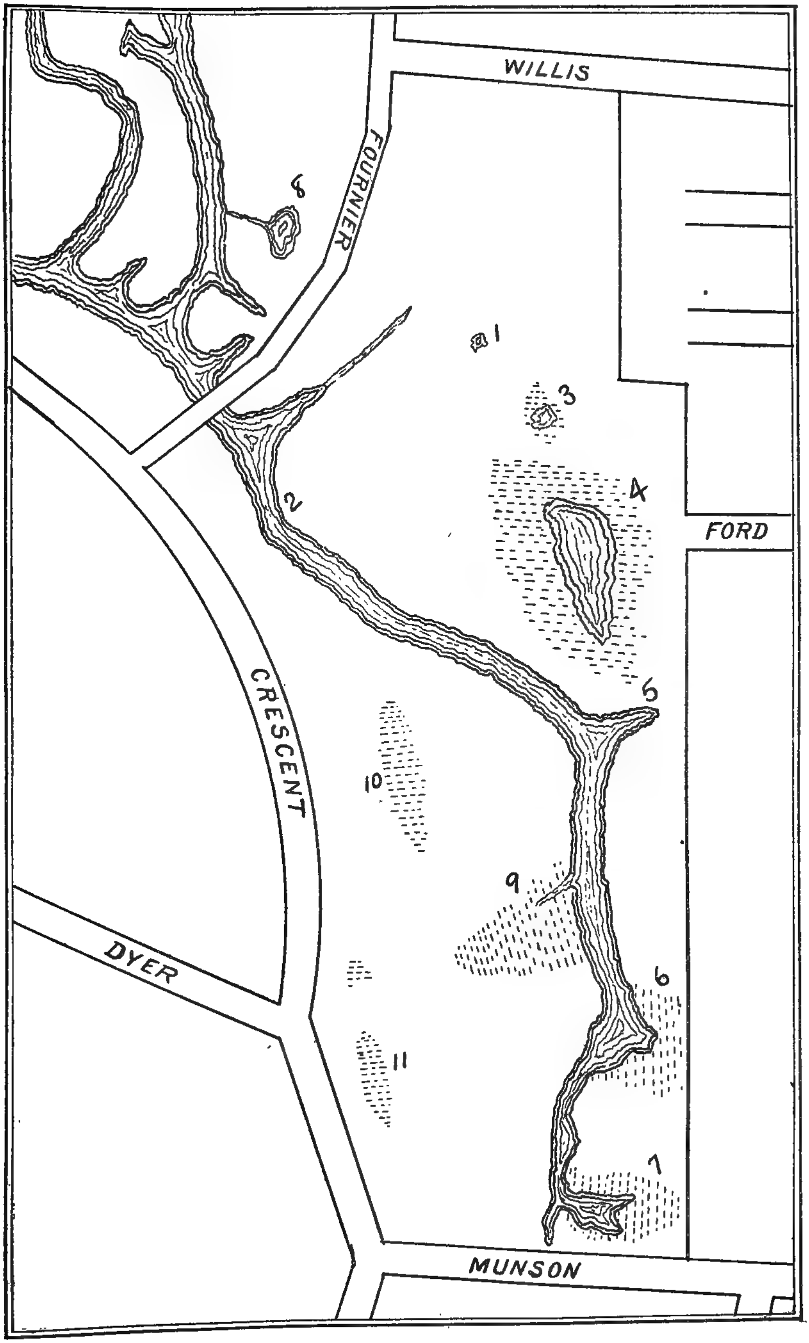

FIG. 10. Map of Beaver Swamp, New Haven, showing breeding-places of the malarial mosquito.

No. 7. A large boggy area covered with cattails and rank growth. In sight of Munson Street. Contains a pond with muddy, soggy edges, so soft that it was impossible to get near enough to test the water. Many bare depressions indicate that water would stand on much of the area in a normal or wet season.

July 18. Again visited the region. Examined No. 5, and found pupæ and larvæ of *Anopheles*.

No. 8. A large pool west of Fournier Street containing fish two to three inches long. Found *Anopheles* larvæ in water cress and grass along the edge.

No. 9. Soggy area with standing water in which *Anopheles* were found.

Nos. 10 and 11. Low areas which contain water early in the season and probably throughout the summer in a wet season.

For a few thousand dollars this entire region could be put in a salutary condition. It is an engineering problem. Though it may not be feasible to drain the bogs entirely, the water can be considerably lowered by draining, permanent pools can be formed and stocked with fish, and if the edges are kept clean, there will be no trouble from mosquitoes.

NOTES ON BREEDING-PLACES AROUND STAMFORD.

On September 23d the writer visited Stamford at the request of Health Officer Dr. F. J. Rogers to look over the possible mosquito breeding-places. In company with Dr. Rogers and Messrs. R. A. Fosdick and J. J. Radley, a trip was made to the chief marsh regions near the city. The map and notes about this area made in 1904 were used for comparison, and though a dry season, no serious breeding areas were apparent.

Before returning we visited a pondhole between Brook and State Streets, north of the railroad, which was mapped in 1904 as being a serious breeding-place. It is a pond which has been partially filled by dumping all sorts of refuse into it. Two or three square rods of water surface remained, and the water was literally filled with *Culex* larvæ. It was estimated that between fifty and one hundred larvæ were taken at a single dip. *Anopheles* were not seen, but doubtless breed here at times. Measures were planned to do away with this nuisance.

INSECTS ATTACKING CUCURBITACEOUS PLANTS IN CONNECTICUT.

Cucurbitaceous plants such as cucumbers, squashes, pumpkins and melons, which are extensively grown in Connecticut, are attacked and injured by a number of species of insects. For several years we have been making observations on them, and the present paper is for the purpose of giving in a few pages a fairly comprehensive account of the principal insect pests of these plants.

For the hasty identification of such insects the following key may be found useful:

BORING IN THE ROOTS AND STEM—

Small, slender larvæ tunneling in the main root or stem below ground ....
Striped Cucumber Beetle, *Diabrotica vittata,* p. 807.

Large, stout larvæ boring in squash stems above ground ....
Squash Borer, *Melittia satyriniformis,* p. 806.

DEVOURING THE LEAVES—

Small (5-7 mm.) yellowish beetles feeding upon the leaves.

Body yellow, marked with three longitudinal black stripes ....
Striped Cucumber Beetle, *Diabrotica vittata,* p. 807.

Body greenish yellow, marked with twelve black spots ....
Southern Corn Root Worm, *Diabrotica xii-punctata,* p. 809.

Large (8-10 mm.) hemispherical beetle, orange marked with black spots, or yellow larva with black spines ....
Squash Lady-beetle, *Epilachna borealis,* p. 810.

SUCKING SAP FROM THE UNDER SIDE OF THE LEAVES—

Small dark green or brownish plant lice, often very abundant ....
Melon Aphis, *Aphis gossypii,* p. 813.

Larger bright green plant lice usually not abundant ....
Squash Aphis, *Nectarophora cucurbitae,* p. 814.

Gray bug with spicy odor (15 mm. when full-grown) ....
Squash Bug, *Anasa tristis,* p. 811.

Small greenish-white scale-like insects on the under leaf surface of plants growing under glass or near greenhouses. Pure-white moth-like adults resting on the leaves, and flying about ....
Greenhouse White-Fly, *Aleyrodes vaporariorum,* p. 815.

THE SQUASH BORER.

Melittia satyriniformis Hübn.

This is the most important enemy of the squash and pumpkin in Connecticut, and causes the vines to wither in July and to die before maturing their crop. Melons and cucumbers are seldom attacked if squashes and pumpkins are plenty.

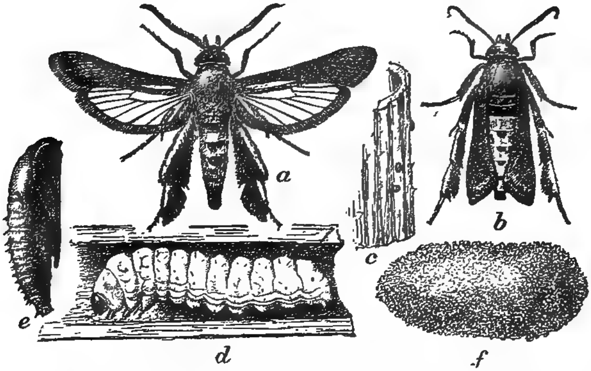

FIG. 11. The squash borer: *a*, male moth; *b*, female, with wings folded as when at rest; *c*, eggs on section of squash stem; *d*, full-grown larva in the stem; *e*, pupa; *f*, pupal cell. All one-third larger than natural size. (After Chittenden, Circular 38, Bureau of Entomology, U. S. Department of Agriculture.)

The adult is one of the clear-wing or sesiid moths, and is shown on Plate L of this report. It has a wing expanse of from one to one and one-fourth inches, and the fore wings are opaque and dark olive green in color with a metallic luster and a fringe of brownish black. Rear wings with transparent cells and a bluish reflection, veins and fringe black. Thorax and antennæ colored about like fore wings. Abdomen reddish brown, legs bright orange, with tarsi black with white bands. When at rest the wings are folded as in *b* of the accompanying illustration (Fig. 11).

This insect is distributed throughout the eastern half of the United States from Canada south to Mexico, and is thought to be a tropical species. The female lays eggs singly on the squash plant during June or early July in Connecticut, but may be abroad at a much earlier date farther south. The eggs are usually laid on the stem, but may often be found on the leaves or buds. The eggs are oval and dull red, and over two hundred may be laid by one moth. From one to two weeks are required for the eggs to hatch, and the larvæ become full grown in about four weeks. The newly hatched larva enters the main stem, where it tunnels through it lengthwise near the base, often going into the leaf petioles which branch from the main stem. As the larvæ increase in size they eat more and more each day, and the plant begins to wilt. This is usually the first sign of the attack, though an earlier examination would show the yellowish excrement which is thrown out of the holes in the stem. The stem usually begins to decay near its base, and is often severed at this point. The full-grown larva is about one inch long, rather stout and soft, is white with a black head and is shown with its injury on Plate L. It goes into the ground one or two inches, where it makes a cocoon of silk, to which adhere small particles of soil. There is only one generation each year in Connecticut, but in Washington, D. C., there are two broods.

In our experiments several remedies have been tried, including wrapping the stems with tarred paper, placing tarred paper disks around the stems at the base, and painting the stems with a thick mixture of lead arsenate. These three practices did not seem worth while. The only treatment that we can recommend is to plant early squashes for traps to be destroyed later; to cut into the stems, making a longitudinal incision, and killing the borers; to cover the stem with earth one or two feet from the base to induce secondary roots that will support the plant in case it should become severed at the base. It is also advisable to destroy all old vines as soon as the crop is secured.

The Striped Cucumber Beetle.

Diabrotica vittata Fabr.

A frequent and serious enemy of all cucurbits is the striped cucumber beetle, *Diabrotica vittata*. Soon after the seedling plants appear the beetles begin to feed upon the leaves and tender stems, eating away the epidermis, often causing the plants to wilt and die. They even burrow into the ground and attack them before they come up.

The beetles are about one-fifth of an inch long, with thorax and wing-covers yellow, the latter with three black longitudinal stripes; the head is also black. At the time the beetles are feeding upon the young plants they are also mating and laying eggs on the stem just below the surface of the ground. The larvæ hatching from these eggs are borers in the roots of the plants, sometimes causing considerable injury. A sample of this work is shown on Plate LI. Though the complete life history of this insect is not well known, it is believed that the larval period lasts for about a month. The full-grown larva is about one-third of an inch long, and is slender and whitish, with a black head (see Fig. 12). Pupation occurs within the ground. The pupa is white, like the larva, and the pupal stage lasts about a week. There are two generations in Connecticut each season, and the beetles are often found in large numbers late in the season assembled under the dead leaves of the plants. Melons, cucumbers, squashes and pumpkins are attacked.

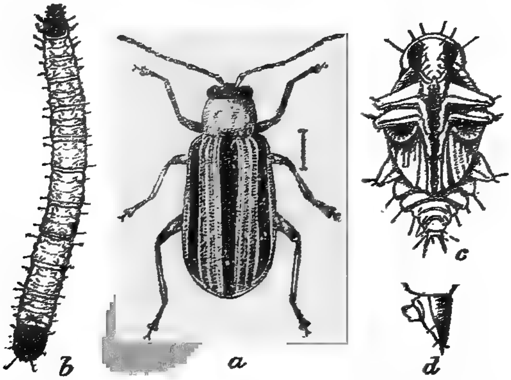

FIG. 12. The striped cucumber beetle: *a*, adult beetle; *b*, larva; *c*, pupa; *d*, side view of anal segment. All greatly enlarged. (After Chittenden, Circular 31, Bureau of Entomology, U. S. Department of Agriculture.)

The remedies consist either in keeping the beetles away from the plants or in the use of poison. The latter method is the one practiced by most large growers. Paris green may be mixed with air-slaked lime or plaster at the rate of one pound of poison to seventy-five pounds of plaster, and the mixture sifted upon the plants. This, of course, cannot be used before the plants come up, and when the beetles are extraordinarily abundant much damage will often result to the plants in spite of the application of poison. Lead arsenate mixed with water at the rate of three to five pounds in fifty gallons of water and sprayed or sprinkled upon the plants is usually an excellent remedy.

In order to keep the beetles wholly away from the plants it is necessary to cover them with frames of netting. A barrel hoop may be cut in two equal parts and fastened together at right angles, the ends set in the ground, and the frame covered with netting. The ends of these semicircular hoops may be fastened to another hoop lying horizontally in order to make a portable frame, and the whole covered with netting. Boxes and various other forms of wood may be designed into protectors for this purpose, but they are chiefly for use in the home garden, and must be placed over the hills before the beetles appear. In some cases it is possible to drive away the beetles by a frequent dusting of the plants with fine coal ashes, air-slaked lime, or insect powder, and some growers use trap plants and practice burning all old plants and rubbish in the field after the crop is harvested.

THE SOUTHERN CORN ROOT WORM OR TWELVE-SPOTTED CUCUMBER BEETLE.

Diabrotica xii-punctata Oliv.

This insect is not usually included in a list of insects injurious to cucurbitaceous plants, but it has been so abundant in certain fields which have come under our observation that surely considerable damage must have been done by it, and for that reason it is listed here.

For many years the adults have been known to feed upon a large number of plants, including nearly all of the common vegetables and some of the fruit blossoms and field crops. The larvæ are a serious pest of corn roots in the Southern States, and also attack rye, millet and garden beans, sometimes doing considerable damage.

The eggs are laid in the soil, each female laying about seventy-five eggs, which hatch in about three weeks, and the larvæ tunnel in the roots of corn and other plants for nearly four weeks, pupating in an earthen cell from which the adult beetle emerges about a week afterward.

The adult beetle is somewhat larger and stouter than the striped cucumber beetle, and averages about 7 mm. in length. The wing-covers are greenish yellow, marked with twelve black spots arranged in three transverse rows, and varying in size. Thorax bright yellow, head black. Legs, except thighs, and antennæ blackish.

Where abundant enough to cause injury, the same remedial measures used against the striped cucumber beetle should be practiced.

THE SQUASH LADY-BEETLE.

Epilachna borealis Fabr.

Nearly all of the lady-beetles are carnivorous, and are considered beneficial because they feed upon injurious insects such as plant lice and scale insects. The squash lady-beetle, however, is an exception, and feeds upon the leaves of cucurbitaceous plants, but does more damage to squash than to the other plants of this group.

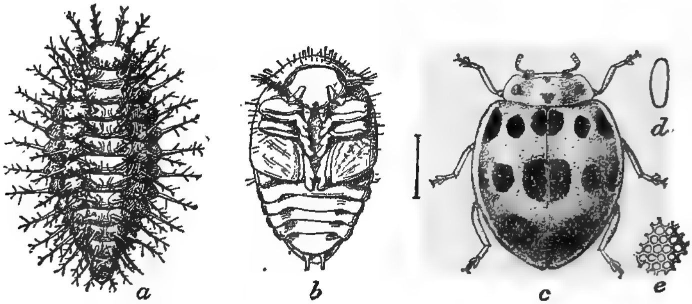

FIG. 13. The squash lady-beetle: *a*, larva; *b*, pupa; *c*, adult beetle, three times natural size; *d*, egg, four times natural size; *e*, surface of same highly magnified. (After Chittenden, Bulletin 19, Bureau of Entomology, U. S. Department of Agriculture.)

The adult beetles hibernate under bark or in other sheltered places, emerging in June, and toward the end of the month lay their eggs on the under side of the leaves. The eggs hatch in about twelve days, and the larvæ at once commence to feed upon the leaves, attacking them from the under side. The larvæ appear about the middle of July and become full grown early in August, when they assume the pupa stage, which lasts six days before the adults emerge.

The adult is nearly hemispherical in shape, slightly oval, about one-third of an inch long and slightly over one-fifth of an inch broad. It is greatly convex, and of a yellowish or reddish brown color marked with black spots, seven on each wing-cover and three or four smaller ones on the thorax.

The larva is yellow, with black branching spines, and about half an inch in length. The spines are arranged in six longitudinal rows. This insect is shown in Figure 13 and on Plate LIII c. Its work is shown on Plate LII b.

The larvæ feed chiefly on the under sides of the leaves late in July and early in August, and the adults are generally found at the same time, as well as both earlier and later, feeding upon the upper surface. The adult has the peculiar habit of marking out with its mandibles a definite area on the leaf and then feeding within this area. It is thought that this procedure causes the tissues to wilt, and that this somehow better suits the insect.

A brief account of this insect was printed in the Report of this station for 1898, p. 269, and more extended accounts of it have been published by Professor John B. Smith, in Bulletin 94 of the New Jersey Station, and by Dr. F. H. Chittenden, in Bulletin 19, New Series (p. 11), of the Bureau of Entomology at Washington.

The squash lady-beetle can be controlled easily by the use of the arsenical poisons.

THE SQUASH BUG.

Anasa tristis De Greer.

The squash bug, or "stink bug," is a serious pest of squashes and pumpkins, though it does not as a rule attack melons and cucumbers. It punctures the tissues of a vein on the under side of a leaf and, sucking out the sap, causes the leaf to wilt badly and die. The adult bugs are about three-fourths of an inch in length, dark gray or brownish, and are rather conspicuous objects on the under surface of the leaves. The eggs are dark brown and

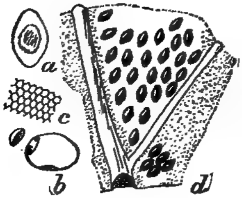

FIG. 14. Egg of squash bug as they are laid on the under side of a leaf. Enlarged. (After Chittenden, Bulletin 19, Bureau of Entomology, U. S. Department of Agriculture.)

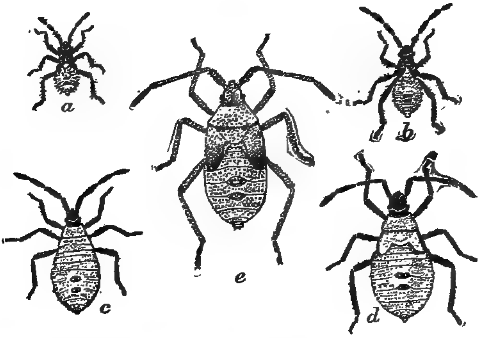

FIG. 15. Nymphs of the squash bug; different stages, about twice natural size. (After Chittenden, Bulletin 19, Bureau of Entomology, U. S. Department of Agriculture.)

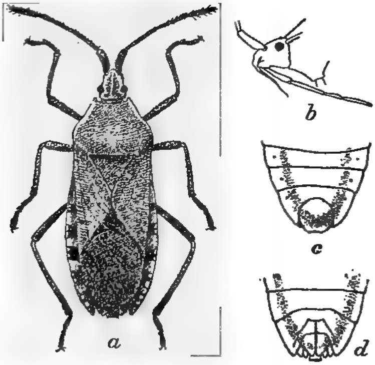

FIG. 16. The squash bug: *a*, mature female, twice natural size; *b*, side view of head showing proboscis; *c*, abdominal segments of male; *d*, same of female. Enlarged. (After Chittenden, Bulletin 19, Bureau of Entomology, U. S. Department of Agriculture.)

shining, and are laid in more or less regular rows in masses containing between twenty and forty each, as shown in Figure 14 and on Plate LII a. The young nymphs hatching from the eggs are ash-gray in color and pass through five distinct stages before reaching maturity, during which time they are found underneath the leaves, getting their nourishment from the sap. The nymphs and adults are shown on Plates LII and LIII. See also Figures 15 and 16.

The adults are hard to kill, but the young nymphs are quite susceptible to applications of kerosene emulsion. Hand-picking and the use of plant protectors such as are used against the striped cucumber beetle are to be advised. Above all, clean-cultural methods, such as burning the old vines after the crop is harvested, are essential.

THE MELON APHIS OR PLANT LOUSE.

Aphis gossypii Glover.

This is really one of the worst insect enemies of this class of crops. It is nearly always present, and being on the under surface of the leaves, where it sucks the sap, it escapes notice until the leaves begin to curl on account of it. On account of its position and the curling of the leaf, it is extremely difficult to strike it with a spray, though this can be done with the proper outfit. The melon aphis is much more injurious to cucumbers and melons than to squashes and pumpkins. When first born, the insects are yellowish green, but they soon take on a darker tinge and finally become brown. This aphis is pronounced by Chittenden* the most injurious plant louse in this country, and it attacks a great variety of plants, among which are cotton and several kinds of vegetables, in addition to the melon and cucumber. Besides these, it is found upon, and is doubtless able to subsist upon, a large number of common weeds. The entire life history of this insect is not known. The species is able to multiply so rapidly that plants are often very seriously injured in a short time, and late in summer it usually disappears very suddenly. See Figure 17.

Our common lady-beetles and syrphus flies prey upon the melon aphis.

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* Circular 80, Bur. of Entomology, U. S. Dept. of Agriculture, 1906.

The most promising lines of treatment are as follows:

Spray the leaves from beneath with kerosene emulsion.

Cover the vines with boxes or tubs, and fumigate with carbon disulphide or hydrocyanic acid gas.

Dust with insect powder or tobacco dust applied by means of a powder gun. Place tobacco stems on the ground around the plants.

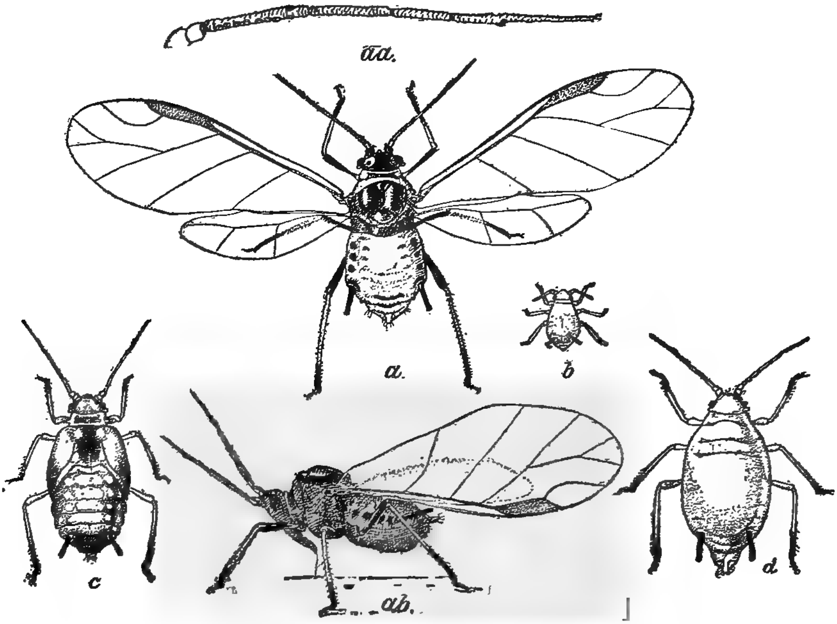

FIG. 17. The melon aphis: *a*, winged female; *aa*, enlarged antenna of same; *ab*, dark form, side view; *b*, young nymph; *c*, last stage of nymph; *d*, wingless female. All greatly enlarged. (After Chittenden, Circular 80, Bureau of Entomology, U. S. Department of Agriculture.)

THE SQUASH APHIS.

Nectarophora cucurbitæ Middleton.

This is a light green species, larger than the melon aphis. It is found chiefly on squashes and pumpkins, though not as a rule causing much damage. The same treatment advised for the melon aphis may be used against this species.

THE GREENHOUSE WHITE-FLY.

Aleyrodes vaporariorum Westw.

Cucurbits growing under glass or out of doors near greenhouses are often attacked and considerably injured by this white-fly. The insect is found on the under sides of the leaves, where the eggs are laid and where the nymphs attach themselves to the leaves. They are very light green, almost white, oval, and resemble scale insects. The empty pupa skins remain on the leaf, and these are silvery white. Adults are pure white and mealy in appearance, resembling tiny moths. They rest upon the under surface of the leaf, where they lay eggs, but fly about when disturbed.

Descriptions and figures of this insect will be found in the Reports of this station for 1902, p. 148, and for 1906, p. 275.

Frequent spraying of the under surface of the leaves with soap and water (one pound in eight gallons) will kill the adults and larvæ and keep the pest in check. Fumigating greenhouses with hydrocyanic acid gas, using one-half ounce of cyanide for each one thousand cubic feet of space, with an exposure of three hours, is perhaps the most effective remedy under glass, but this must be repeated frequently, because the eggs are not all killed by a single treatment, while if more cyanide be used or a longer exposure given, there is danger of injuring the plants.

THE ELM LEAF BEETLE.

Galerucella luteola Müll.

During the past summer (1908) the elm trees of Connecticut have been injured more seriously by the elm leaf beetle than for several years. Many persons thought that the pest had run its course, and that never again would it do much damage to the shade trees of this part of the country. But they were mistaken. In some parts of the state, and especially along the coast, the elm trees were partially defoliated by canker worms in May, with more or less feeding, of course, by the adult elm leaf beetles. The canker worms disappeared about June 1st, and were followed immediately by the newly hatched larvæ of the elm leaf beetle, which devoured the green substance of the under side of the leaves, in many cases completing the defoliation of the trees.

The season was a dry one, and though most of these trees put out a sickly growth of new leaves, it would have been much stronger in a wet season, and therefore less damaging to the trees.

Specimens of the elm leaf beetle were received from eleven different correspondents, representing the following parts of the state: Branford, Bridgeport, Ellington, Hartford, Meriden, Moosup, New Canaan, North Stonington, Rowayton and Wapping. From three of these localities (Branford, Meriden and Moosup), specimens of natural enemies of the beetle were received. These are discussed on page 821.

In addition to the samples received during the season, this office has received and answered fifty-five letters and many telephone calls regarding the pest. The inquiries came from all parts of the state, though most frequently from the southern half, Waterbury reaching first place in regard to the number of inquiries.

As no comprehensive account of the elm leaf beetle has been published in the later station Reports, and only scattered notes have been given therein from time to time, it was thought best to include the matter here. A portion of this paper appeared as Bulletin 155 in June, 1907, but a number of additions have been made to it as here given.

HISTORY AND DISTRIBUTION IN AMERICA.

The elm leaf beetle was introduced into this country probably more than seventy years ago. In its native country, Europe, where it had long been known, it had from time to time caused serious injury in Italy, Austria, and the southern portions of France and Germany. In Northern Europe the insect occurs sparingly, but can hardly be called a pest. Harris states* that the elm leaf beetle attacked and seriously injured the elm trees of Baltimore, Md., in 1838 and 1839. The beetle seemed to spread chiefly northward, though slowly, until Southern New England was reached in the early nineties, and much damage done. In the coast towns of Connecticut many fine old elms, including some historic trees, were killed by its depredations. Stamford, Norwalk, Bridgeport, Stratford, Milford and New Haven especially lost many noble trees. Later the inland cities were invaded, and the elm trees ravaged. In New Haven the pest was perhaps at its worst in 1895 and 1896. In 1896 many of the trees on the older streets about the center of the city were sprayed with poison by the street department. The following season the pest was less serious, and continued to subside until 1901, when it was again comparatively destructive. From 1902 it diminished in abundance until 1906, when considerable damage was done to the trees.

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* Insects Injurious to Vegetation, page 124.

So far as is known the distribution of this insect in America is confined to the lower altitudes of Southern New England and the Alleghanian region. From Charlotte, N. C., its southern limit, the elm leaf beetle now extends as far north as North Conway, N. H. Up to this time, however, the beetle has done no particular damage in New Hampshire. Regions generally infested include the whole of Massachusetts, Rhode Island, Connecticut, Southeastern New York, New Jersey, Eastern Pennsylvania, Delaware, Maryland and a portion of Kentucky, though isolated outbreaks have occurred in Western New York, Pennsylvania, West Virginia, Ohio and North Carolina. It is of course found in Virginia, Vermont, New Hampshire, and probably in Maine. Kentucky, therefore, contains the western limit of the distribution of this insect, though we may expect that soon adjoining states may become infested. The insect exhibits a marked tendency to spread farther along river valleys than over mountains, and is distinctly a pest of city and village trees rather than of trees in the open fields and roadsides of the country.

LIFE HISTORY AND HABITS.

The overwintering beetles come out of their winter quarters during the warm days of early spring, mate, and as soon as the leaves unfold they begin to eat small round or oval-shaped holes through them. Many leaves are thus riddled as though shot had been sent through them, and appear like the illustration on Plate LIV b of this Report.

During the latter part of May and early in June females deposit small clusters of yellow eggs on the under sides of the leaves. The period of ovipositing extends over about four weeks, and each female may lay five or six hundred eggs. In about a week the eggs hatch and the young larvæ or grubs feed upon the under surface of the leaves, eating off the green tissue between the veins and leaving the veins and the upper epidermis, as is shown on Plate LIV a and c.

In about three weeks the larvæ or grubs are fully grown, and crawl down the trunks of the trees or drop from the ends of the branches to the ground and transform to the naked pupa stage. The great proportion of the pupæ are found close around the base of the tree or lodged in the crevices of the rough bark of the trunk and larger branches. Except for being in crevices, they are unprotected. The writer has seen trees in New Haven where it would be possible to gather several quarts of these pupæ at the base of a single tree.

The pupa stage lasts about ten days, then the adult beetles appear, and lay eggs for the second generation, which seldom does much harm in Connecticut. Those emerging late probably do not lay eggs for a second brood, but may be seen crawling and flying about for a time, feeding more or less, but early going into winter quarters, usually in church belfries, attics of houses, barns, sheds or other out-buildings. They also pass the winter in cracks of fences, telephone poles, or under the edges of the loose bark of the trees. In some of the cities worst infested the adults sometimes gather in church belfries in such numbers that they can be swept up by the half bushel. The elm leaf beetle often occurs with the two-spotted lady-beetle in dwellings, simply because they both seek the same kind of a place for hibernation. Correspondents frequently send both species to the writer and desire to know if they are not in some way responsible for the injuries to their carpets. There is, of course, no relationship or similarity in food habits of the three species. The lady-beetle is predatory, and in the larval stage destroys numbers of plant lice, and therefore should never be destroyed. The elm leaf beetles should, of course, be killed wherever they are found.

DESCRIPTION.

The *eggs* are bright yellow in color, bottle-shaped, and resemble the eggs of the Colorado potato beetle, but are smaller. They are fastened vertically to the under side of the leaf in clusters of from five to twenty-five arranged in two or three irregular rows.

When first hatched, the *larva* is dark or nearly black, covered with tubercles bearing black hairs. As the larva increases in size it molts several times and on becoming full grown is about one-half inch long, dull yellow in color, with a pair of longitudinal black stripes along the back. Head, legs, lateral tubercles and two rows of small tubercles between the dorsal stripes are black. The tubercles also bear black hairs.

The *pupa* is about one-fourth inch in length and bright orange yellow in color, with black hairs or spines. It is not enclosed in an earthen shell to protect it, but is found at the base of the tree perfectly naked and wholly unprotected.

The *adult beetle* is light yellow in color when it first emerges, but soon takes on a duller hue, and finally becomes a dull olive green. An indistinct black stripe extends from the base to the extremity of each wing-cover just inside of the margin. Small black spots or markings on the pronotum of the thorax vary greatly in size and shape. Legs and antennæ are yellow.

Eggs, larvæ, pupæ and adults are shown on Plate LV.

EFFECT UPON THE TREES.

It has previously been mentioned that the adult beetles do more or less feeding, always eating holes entirely through the leaves, as is shown on Plate LIV b. This of course injures the tree, but is much less serious than the damage caused by the larvæ, which eat away the under surface of the leaves. The larvæ are always more abundant than the adult beetles, and are more voracious in their feeding habits. The worst infested trees usually drop their leaves in Connecticut about the middle of July. If this happens, and is followed by a rainy season, new leaves will be put out, but in a season of a protracted drought the trees may fail to put forth new leaves. In either case the tree is undoubtedly weakened, and often seriously so. Sometimes the second crop of leaves is devoured by the second generation of beetles, but in Connecticut the white fungus mentioned in another part of this bulletin is apt to serve as an important check to the beetle in a wet season. Two complete defoliations, one succeeding the other, usually kill a tree. Usually, however, the defoliation is not quite complete, and the trees continue to exist in a greatly weakened and devitalized condition. In the cities and larger towns, on account of further injuries* by horses, by leaky gas pipes in the ground, and pavements which cut off the supply of moisture, many trees have died. In 1901 the writer was called to Norwich, where nearly every elm had died for a distance of about one and one-half miles on a prominent residential street. These trees had been weakened by the constant attacks of the beetle year after year, and a leaky gas main finally destroyed what little vitality remained. Most of the maple trees along the street survived.

In many cases young or newly planted trees seem to be especially subject to attack, and therefore should receive extra attention.

FOOD PLANTS.

Elms constitute the only food plants known for this insect, and the European species suffer more than the American ones. The English elm (*Ulmus campestris*) and its weeping variety known as the Camperdown elm are favorites of the beetle. The writer has seen these trees entirely defoliated in New Haven when the common white, or American elms, were uninjured. The American elm is, however, the next choice, followed by the Scotch elm (*U. montana*), and though no variety is wholly exempt from attack, the winged elm (*U. alata*), the slippery elm (*U. fulva*), the cork elm (*U. suberosa*) and the rock elm (*U. racemosa*) are much less frequently attacked.

NUMBER OF GENERATIONS.

According to Burgess,† "in New Jersey, Professor J. B. Smith has recorded only a single brood and sometimes a partial second brood, while in the latitude of Washington, D. C., according to the observations of Messrs. Riley, Howard and Marlatt, of the Division of Entomology, two annual broods and sometimes a partial third brood have been found."

Dr. E. P. Felt, state entomologist, of Albany, N. Y., finds‡ two well-marked broods and a partial third brood at Albany and Troy, N. Y.

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* For a discussion of these injuries the reader should consult Bulletin 131 of this station.

† Bulletin No. 4, page 17, Ohio Dept. of Agriculture, Div. of Nursery and Orchard Inspection, 1905.

‡ Bulletin No. 57, N. Y. State Museum, p. 14, 1902.

The writer has not followed out this matter carefully in Connecticut, but all stages are found on the trees during the first half of September, so presumably there are at least two broods, but the egg-laying period of the adults is so prolonged that the lines of demarcation are nearly obliterated. In Connecticut the leaves of the trees severely attacked by the first brood generally turn brown and drop about the middle of July, when the larvæ are descending the trees to pupate.

NATURAL ENEMIES.

One of the most important natural enemies of the elm leaf beetle in Connecticut is a fungus known to botanists as *Sporotrichum globuliferum* Speg. (*S. entomophilum* Peck), which attacks the pupæ and adults in late summer, especially in a moist season. In 1902 this fungus was prevalent, and the following season the elm leaf beetle did little damage to the trees. In 1906 the beetles were abundant, but as the month of July was wet, the fungus developed and killed a great many beetles. Beetles attacked by this fungus are covered with white mold, as shown on Plate LV e.

In 1907 the elm leaf beetle, though doing some damage throughout the state, was much less serious than in 1906, but an extreme drought prevailed, almost no rain falling during July and August, and the fungus could not get in its work. Consequently most of the beetles matured and transformed, and were ready to attack the trees in 1908, doing serious damage. It was also very dry in 1908, and the *Sporotrichum* could not prevail. After a light rain late in July the writer saw a number of infested pupæ and adult beetles, but it was after most of them had transformed and the beetles flown away, and the rain soon dried up, making it impossible for the fungus to continue to develop. These conditions indicate, therefore, that the pest will be abundant and destructive next year, and all citizens should be ready to combat it.

The writer believes that the fungus just mentioned constitutes an important check on the beetle in seasons when there is much moisture at the time of pupation, and this view is also shared by Dr. G. P. Clinton, botanist of this station, who has observed its work in this vicinity.

In Europe there is a minute chalcidid parasite known as *Tetrastichus xanthomelænæ* Rond. which attacks the eggs of the elm leaf beetle, and at times proves an effective check. After many trials, this parasite has during the past season been introduced into this country through the efforts of Dr. L. O. Howard,* and has been distributed in Massachusetts, New York, New Jersey, and at Washington, D. C. It is hoped that it may survive here and prove an important aid in controlling this pest.

Predatory bugs of at least three species of the genus *Podisus*, called "soldier bugs," feed upon the larvæ and pupæ, and one of these, *P. maculiventris* Say (formerly *P. spinosus* Dall.), the spined soldier bug, was unusually abundant during 1908 and destroyed many larvæ, pupæ, and adult beetles, though of course the proportion destroyed is very small. The spined soldier bug was sent in from Branford, where its attack on the beetles was observed by Mrs. A. J. Tenney; from Meriden and from Moosup, where it had also been found preying upon the elm leaf beetles. From Bridgeport dead beetles were received, having been killed by one of these bugs. The writer observed a number of cases in New Haven where larva, pupa or adult had been attacked by the spined soldier bug, which impaled the victim upon its proboscis and waved it about in the air while sucking out the juice. These bugs were rather common on trees during the last of July and the first part of August, and are shown on Plate LV d. Dr. A. W. Morrill† has published a record of two of these bugs in confinement which during their last nymphal stage destroyed twenty-six elm leaf beetle larvæ, and after becoming adults destroyed two hundred and twenty elm leaf beetle larvæ and seven large caterpillars.

Riley records‡ two species of beetles, *Platynus punctiformis* and *Quedius molochinus*, as preying upon the elm leaf beetle, and states that an assassin bug, *Reduvius novenarius*, sucks the juices of both adults and larvæ upon the leaves, and that the larva of a species of *Chrysopa* feeds upon the eggs.

The praying mantis (*Stagmomantis carolina* Linn.) is also an enemy of the elm leaf beetle in the southern portion of its range.

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* Journal of Economic Entomology, Vol. I, p. 281, October, 1908.

† Bulletin No. 60, Bur. of Entomology, U. S. Dept. of Agriculture, p. 155. 1906.

‡ Bulletins No. 6, p. 10, and No. 10, p. 13, Bur. of Entomology, U. S. Dept. of Agriculture.

Birds of various kinds are known to feed upon the beetles in their larval, pupal and adult stages. Some of the creepers have been observed apparently feeding upon the pupæ.

REMEDIES.

Spraying with poison. Covering the foliage with some arsenical poison is the only sure means of preventing injury to the trees, and for this purpose arsenate of lead is unquestionably the most satisfactory of these poisons. It remains better in suspension and adheres to the foliage longer than Paris green or London purple, and is less liable to injure it. As there are now several brands of good arsenate of lead on the market, it will no longer pay to make it up each time from lead acetate and arsenate of soda. The standard brands of lead arsenate on the market are as a rule satisfactory and many of them have been used in our tests. If anyone desires to know the chemical composition of these preparations he should consult Bulletin 157, or the Report for 1907, p. 323, of this station, both of which give the analyses of most of the brands which were sold on the market in 1907. Since then a few new brands have been added, some of which have been examined here. It is fair to state that it is safe to purchase any of them if made by well-known and reliable firms, though as the published analyses show, there is considerable difference in the value on account of the composition and each purchaser should obtain guarantees and prices before buying in large quantities. There are also certain differences in mechanical condition which should be considered. Arsenate of lead should be used in the following proportions:—

Formula		
	Arsenate of lead	3–5 lbs.
	Water	50 gals.

There are two methods of spraying elms: (1) To spray as soon as the leaves unfold, the treatment being aimed especially at the parent beetles, and to forestall all injury. This treatment should be practiced wherever canker worms are destructive. As growth takes place, new leaves are constantly appearing, and these will not carry poison unless the application is from time to time repeated. This should be done often enough to keep the foliage well coated with poison until July 1st, when growth usually ceases, and both sides of the leaves should be coated.

(2) The other method is to spray the under sides of the leaves very thoroughly about June 1st, or soon after the eggs begin to hatch. This treatment is aimed at the larvæ, and sometimes a single spraying is sufficient, as the poison will remain throughout the season. By it the great bulk of damage will be prevented, but the leaves will show the small holes made by the parent beetles before the poison was applied.

If arsenate of lead cannot be procured and it seems desirable to use other poisons, Paris green can be substituted.

This should be used at the following rate:

Formula	Paris Green	1 lb.
	Fresh lime	3 lbs.
	Water	50 gals.

Paris green is quicker in its action upon the insects than arsenate of lead, but will not remain as long upon the trees. Unless the lime is added, there is danger of "burning" the leaves. Lime is not needed with arsenate of lead.

The cost of spraying elm trees will vary from ten cents each in case of small trees to five dollars or more for the largest trees, according to the price of labor and the efficiency of the outfit.

Destroying the pupæ. If the trees have not been protected by spraying, and have been attacked and injured by a horde of beetles and their larvæ, it is always advisable to destroy the insects in the pupa stage at the base of the trees, in order to reduce the crop for next year as much as possible. These can often be swept up in large quantities; they can be killed by sprinkling them with hot water; but best of all is to spray the ground not only close to the tree but as far away as the branches reach, and also spray the bark of the trunk and large branches, with kerosene emulsion or some other contact insecticide. The pupæ are easy to kill, but as they remain in the pupa stage only about ten days, it is essential that this work be done at the right time, and it is only when we observe that most of the larvæ descending the trunk have transformed to bright yellow pupæ that we can know when is the proper time to act.

Destroying the adult beetles. The beetles should of course be destroyed in attics, belfries and other places where they hibernate. This can best be done by sweeping them up before they become very active in spring and dropping them into the fire, hot water or kerosene to kill them.

OUTFIT FOR SPRAYING ELM TREES.

The barrel hand-power pump can be used for spraying small trees or for a limited number of large trees, but if one expects to make a business of spraying street trees, it will pay to procure a power sprayer; this may be a steam or gasoline engine with pump; and still another kind is the "Niagara Gas Sprayer," which utilizes cylinders of carbonic acid gas to furnish pressure, thus doing away with a pump. Each large village and city should have at least one power sprayer that can be put to immediate use for spraying street or park trees. Strong one-half inch hose should be provided in long lines of from fifty to two hundred feet, and from four to six of these can be attached to each power sprayer. Even a larger number might be attached, but while in operation some workmen would be in the way of others, so that nothing would be gained. Mr. H. L. Frost of Boston, who is in the spraying business, informed the writer that four lines of hose is about the most economical number for each outfit. Each hose is furnished with an extension rod with closing valve at the lower end and a cluster of nozzles at the upper end. These rods should be of different lengths, from four to twelve or fourteen feet for the different kinds of work. Any of the standard nozzles such as "Vermorel," "Mistry," or "Spraymotor" will be found satisfactory, and if several are used together in a cluster one is able to cover more leaf surface in a given time.

For getting about in tall trees it will be necessary for the men to be provided with climbing irons and extension ladders.

On account of the serious condition of the trees throughout the state, and the many inquiries and misleading letters in the newspapers from individuals, the following statement was given to the press in July:

Many elm trees in various portions of the city have lost nearly all their leaves from the attacks of the elm leaf beetle. The injured leaves have been dropping for several days, and the trouble has been aggravated by the extreme drought. Had it been a wet season, many of the beetles would probably have been killed by the fungous disease which attacks them.

The damage has nearly all been done for this season, as the partial second brood is usually of little account. The larvæ or grubs are now crawling down the trees to transform to pupæ at the base. Many property owners have placed bands of sticky fly paper around their trees and have caught some of the larvæ, but most of them are prevented from coming down and will transform above the bands. It is probably better to let them descend where they can be reached easily and killed.

The bright yellow pupæ at the base of the tree and lodged in the crevices of the bark should be destroyed at once. This can be done easily by spraying them with kerosene emulsion or common laundry soap dissolved in water at the rate of one pound in eight gallons. They can also be swept up and burned or dropped into a pail of kerosene or of hot water.

Prompt action is necessary, for the pupa stage lasts only ten days, when the beetles appear and fly away. They do but little feeding, and go early into barns, attics and church belfries, where they pass the winter. The beetles can sometimes be gathered in large numbers and should always be destroyed.

Trees which have lost their leaves this season should be sprayed with poison (three pounds lead arsenate in fifty gallons of water) next year to preserve the foliage, for if completely defoliated for two or three seasons successively the trees will die. The poison should be applied in the form of a spray directed against the under surface of the leaves, where the larvæ or grubs feed.

People always become excited and wish to "save the trees" at this time of the year, after the damage has been done for the season. They should begin earlier, and spray the trees in time to prevent the injury.

WHAT TO DO.

1. Destroy all of the bright yellow pupæ at the base of the tree and in the crevices of the bark.
2. Hunt for beetles in houses, barns, attics, church belfries, and out-buildings during the fall, winter, and early spring, and destroy them.
3. Arrange to spray the trees with poison next year.

Information concerning this pest may be obtained at any time from the Connecticut Agricultural Experiment Station at New Haven. Bulletin 155 gives a complete account of the insect, and will be sent on request as long as the supply lasts.

W. E. BRITTON,
State Entomologist.

SUMMARY.

The elm leaf beetle was introduced into this country from Europe about seventy years ago, and caused serious injury to trees at Baltimore, Md., in 1838 and 1839. From this point it spread slowly, chiefly to the northward, reaching Connecticut in the early nineties, and injuring and killing many fine old trees in the coast towns. Later, inland towns were attacked, and the trees ravaged. The insect is now found from Charlotte, N. C., as far north as North Conway, N. H., and as far west as central Kentucky, but has not proven destructive to elm trees north of Massachusetts. It is preëminently a pest of shade trees in cities and towns, and seldom injures trees in the open fields. Since 1896 the attacks have diminished, but the pest was again serious in 1906.

The winter is passed by the adult beetles in attics, belfries and cracks in fences, and they come forth in April, and later feed and lay their yellow eggs upon the unfolding leaves. Beetles eat holes through the leaves, eggs hatch in a week, and the larvæ eat off the green tissue from the under surface, causing the leaves to turn brown and fall about the middle of July, at which time the larvæ are about full grown. Then they descend to the base of the tree and transform to naked pupæ; ten days later the adult beetles emerge and lay eggs for the second brood or go early into winter quarters.

Two complete defoliations in succession will kill a tree.

How to Fight the Elm Leaf Beetle.

1. Search all attics, church belfries and cupolas for the dormant beetles in winter and early spring. Sweep them up and burn them.

2. Spray the leaves with poison as soon as they have opened, if their shot-hole appearance shows that the beetles are there in abundance, and the under sides of the leaves should be coated about June 1st to destroy the larvæ or grubs.

3. When, later in the season, the yellow pupæ appear on the trunks of trees and the ground beneath, kill them with a spray of kerosene emulsion or by sweeping them up and burning or soaking with kerosene.

The first and third measures should be taken by each householder, church or social organization, at individual expense. The spraying, which is difficult and expensive if the trees are large, can only be done by concerted action of the town or borough authorities. For extensive spraying work power sprayers are desirable, but small elms or a few large trees can be treated successfully by means of a hand-pump of barrel size. The "Niagara gas sprayer" in operation is shown on Plate LVI.

THE GREEN CLOVER WORM A PEST OF BEANS.

Plathypena scabra Fabr.

Late in June the writer noticed that the bush and pole beans in his garden were being eaten by some insect, and during the first half of July complaints were received from five or six different persons who reported that their beans were being devoured. These complaints were mostly from around New Haven, but included one from Meriden. Similar injury to beans was observed upon the station grounds, and in several gardens, and was reported from the eastern portion of Massachusetts and from Virginia.

Though in the South there are several insects feeding upon the plant, it is quite unusual for beans in Connecticut to be attacked by any leaf-eating insect that noticeably defoliates them, and at first we supposed this pest to be *Ogdoconta cinereola* Guen., which Chittenden mentions* as a green striped caterpillar which feeds upon bean leaves.

IDENTITY ESTABLISHED.

From a lot of caterpillars placed in breeding cages on July 14th, some of which began at once to pupate, about twenty specimens were raised, all of which proved to be *Plathypena scabra* Fabr., one of the commonest of our deltoid moths, usually known as snout-moths. No other species were reared from this material, so the evidence is conclusive that *P. scabra,* which is called the green clover worm, is responsible for the damage. After rearing the adults, the writer corresponded with Dr. Chittenden, who kindly called attention to his published article* on this insect, which up to that time had escaped the writer's notice. From this article are taken some of the facts herein set forth which were not observed by the writer.

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* Insects Injurious to Vegetables, p. 113.

INJURY TO BEANS AND OTHER FOOD PLANTS.

Both common beans and Lima beans were attacked and the leaves more or less riddled with irregular-shaped holes. In the worst cases only the veins were left, and the pods were eaten in some instances. The caterpillars were usually found on the under side of the leaves, and on being disturbed the small ones would descend from silken threads, while the larger caterpillars would drop to the ground, wriggling violently and throwing themselves about. Different sized caterpillars were feeding at the same time, some being about full grown and others not more than one-third grown.

By the middle of July, after receiving the complaints and making observations, it was rather difficult to find an abundance of caterpillars, most of them having pupated, though evidences of their work remained. In one garden peas were devoured, and according to Chittenden† other food plants are clover, soy beans, tickweed (*Meibomia sp.*), vetch, strawberry and blackberry. Clover is considered as the usual food plant, but almost any species of the Leguminosæ may serve as food.

LIFE HISTORY.

A nice lot of material was brought to the laboratory on July 14th and was placed in breeding cages in the insectary. One caterpillar pupated in the box, and was not transferred to the breeding cage. On July 24th the adult emerged from this cocoon.

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* The Green Clover Worm, Bulletin 30, Bur. of Entomology, U. S. Dept. of Agriculture, p. 45, 1901.

† *Idem.*

Another specimen emerged July 29th from a cocoon formed July 16th. Thus from ten to fourteen days are passed in the pupa stage. According to literature the eggs require from four to six days for hatching, and the larval stage occupies about twenty-five days. Chittenden finds three generations of this species in the latitude of the District of Columbia, though Coquillett found only two broods in Illinois. The moths do not appear with any particular regularity, as they are found throughout the latter part of the summer, specimens in the station collection bearing dates ranging from June to November.

DESCRIPTION.

Egg. The eggs of this species were not observed by the writer. Though adults were kept in the breeding cages with fresh material of the food plants, all died without laying eggs. Chittenden quotes* Coquillett's description in stating that they are globular and flattened, with the upper half deeply grooved and light in color. The average measurements showed them to be 0.5 mm. in diameter and 0.35 mm. in height.

Larva. About 25 mm. (one inch) long when fully grown, about 3mm. thick in thickest portion near middle, from which it tapers slightly toward the head and considerably toward the posterior extremity. Color light green, striped longitudinally with darker green and fine white or cream-colored lines. Head pale green, shining and hairy. Thoracic legs of the same color as the head. Three pairs of abdominal pro-legs in addition to the anal pro-legs. Each segment bears dorsally, ventrally and laterally a number of dark hairs.

The description just given is of the caterpillar in next to the last stage. In the last stage it is not striped, but nearly uniform in color, paler green and stouter than in the preceding stage. The larva loops in crawling, like the cabbage looper, but it is much more slender, and is not likely to be mistaken for that species.

Pupa. The first pupa obtained was formed in a pasteboard box, and was enclosed in a white silken web or cocoon of rather loose texture. Some larvæ pupated in a rolled leaf, though others went into the ground just beneath the surface and formed earthen cells by fastening together particles of earth with silk threads.

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* Bulletin 30, Bur. of Entomology, U. S. Dept. of Agriculture, p. 45, 1901.

The naked pupa is dark brown in color, about 12 mm. (one-half inch) long and 3 mm. thick. A dorsal ridge extends from the head over the thorax and first four segments of the abdomen.

Adult. The moth has a wing expanse of from one to one and one-half inches, and in general is a dark purplish brown color with the fore wings more or less distinctly mottled with bluish gray, brown and black. The rear wings are very broad, smoky brown, and without markings. It is an extremely variable species, some specimens, especially males, being nearly uniform in color, while others, usually females, show very distinct markings. Ordinarily the females have somewhat less than half of the apical portion of the front edge of the fore wing marked with light bluish gray. Basally this extends across the wing in some cases, but apically it is limited by a blackish or brownish, more or less suffused mark, which extends diagonally from the apex of the fore wing, becoming less distinct toward the point where the base of the gray patch meets the rear margin of the wing.

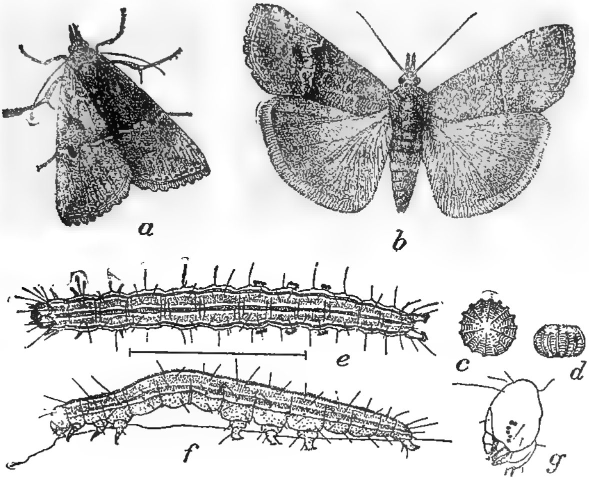

FIG. 18. The green clover worm: *a*, moth in natural position with wings folded; *b*, same with wings expanded; *c*, egg from above; *d*, side view of egg; *e*, penultimate stage of larva, dorsal view; *f*, same from side; *g*, head of larva. All enlarged. (After Chittenden, Bulletin 30, Bureau of Entomology, U. S. Department of Agriculture.)

The palpi are prominently elongated, and project in front of the head, as is the case with other members of this group, which on account of it are called snout-moths. They are called deltoid moths on account of the distinct triangular shape which they assume when at rest with wings folded.

The appearance of all stages of this insect is shown in Figure 18 on p. 831 and on Plate LVII of this Report. A technical description of the adult has been published by Professor J. B. Smith* with synonymy.

REMEDIES.

It is to be regretted that experiments were not conducted with different insecticides, but at the time of the complaints most of the damage had been done, and the larvæ had disappeared.

In case of Lima and other "shell" beans, the plants could be sprayed with lead arsenate, but any poison would be out of the question on string or snap beans, where it may be possible to apply air-slaked lime or some other fine powder by means of a blow-gun to suffocate the larvæ. From their habit of dropping when disturbed the writer has suggested that the vines be brushed or shaken and the larvæ caught in a dish of kerosene or killed upon the ground. No doubt a good spraying of the under side of the leaves with strong soap and water would kill many of the caterpillars, especially the smaller ones.

Usually this insect feeds upon clover, and the damage is so slight that no remedial treatment is necessary.

TREATMENT OF CABBAGE PLANTS TO PREVENT INJURY BY THE CABBAGE MAGGOT.

By W. E. Britton and B. H. Walden.

MOUNT CARMEL EXPERIMENTS.

In the Report of this station for 1906, page 301, there was published a note about dipping plants in a mixture of lead arsenate to prevent injury by the cabbage maggot, *Pegomyia brassicæ* Bouché. This practice was continued in 1907, but in both these years the insect was so scarce that very little harm was done to the plants by it, consequently the experiments failed to show anything.

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* Revision of the Deltoid Moths, Bulletin 48, U. S. National Museum, p. 111, 1895.

In the spring of 1908, tests of various substances and devices were made on the grounds of Mr. Howard C. Yale at Mount Carmel, where the crop had been troubled each season for several years by the maggot. The tests were made on thirteen rows of plants, each row containing about one hundred and thirty-five plants. The rows extended in a northerly and southerly direction, and at the north end the ground was four or five feet higher than at the opposite end of the field.

Rows 1 and 2 were set April 18th, and the plants dipped in lead arsenate (one pound in two gallons of water), Jersey Wakefield in Row 1 and Henderson's Summer in Row 2. Rows 3 to 8 were set about a week later, and Rows 9 to 12 still later, with untreated plants of these varieties.

On May 14th, Rows 3 and 4 were treated with carbon disulphide. A hole at least an inch deep was made near each plant and from one-third to one-half a teaspoonful of the volatile liquid was injected from an oil can and covered up.

Row 5 was left as a check.

Row 6. On May 4th tarred paper disks were placed around a portion (about one hundred) of the plants, beginning at the north end of the row. These disks were a year old and had become dry and stiff, and consequently did not fit as well around the stem nor as close to the ground as when fresh. On May 6th, placed fresh disks on the remaining plants in Row 6 and on the plants in Row 7. These disks were cut with a knife from a single-ply tarred paper.

Row 8, beginning at the north end, seventy-four plants were treated May 6th with the lime-carbolic mixture, made by slaking fresh quicklime, and one quart of the thick cream added to one gallon of water. To this was added about one teaspoonful of crude carbolic acid, as used by Professor J. B. Smith* of New Jersey. The mixture was then sprayed upon the soil around each plant in a circle six to eight inches in diameter.

On May 16th, all of the plants in Rows 8 and 9 were sprayed with the lime-carbolic mixture. Used eight ounces of lime to one gallon of water and 15 c.c. of crude carbolic acid. On this date we were not able to detect any signs of the work of the maggot.

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* Bulletin 200, New Jersey Agr. Expt. Station, p. 18, 1907.

Rows 9, 10, 11 and 12 were treated with salt on May 30th by the owner, nearly a teaspoonful to each plant being placed around the stem at hoeing time. This treatment was evidently too late, as the maggot had already begun its work on some of the plants in the other rows before this date.

Mr. Walden visited the field May 28th and examined the plants. A few were beginning to wilt from the attacks of the maggot on rows treated with lead arsenate, carbon disulphide and carbolic-lime mixture. On digging, maggots were found at the base of most of these wilted plants. The two rows treated with the tarred paper disks looked the best of any and showed no indication of the presence of maggots.

On May 29th and 30th, carbon disulphide was injected around each of the plants in the two rows which at setting had been dipped in lead arsenate, and likewise in the two rows treated earlier with carbon disulphide. This time a hole about one inch in diameter and three inches from the stem, slanting toward the root, was made with a pointed stick, and the liquid was injected through an oil can, using one pound to one hundred plants, or about one-sixth of an ounce per plant.

On June 6th, Mr. Walden visited the field and made a record of the infested plants. Rows 1 to 5 contained from two to nine infested plants per row, the first four rows each having more than the check (Row 5). Row 8 had four infested plants. Row 6 had none and Row 7 had but one. These two rows were treated with the tarred paper disks. Rows 9 to 12 showed no infestation, but as they were not set out until considerably later than the others, it is doubtful if the result should be attributed to the application of salt, which was made too late to entirely keep away the maggots.

Another examination of the plants was made July 3d, and they were found to be in about the same condition as on June 6th, except that those plants which had wilted beyond recovery had been removed, some slightly injured plants had recovered and were beginning to head, and no additional plants showed the attacks of the insect. A few of the plants were well headed and ready to cut.

The plants were all cultivated and hoed about every ten days, and an application of commercial fertilizer with the addition of nitrate of soda was made at the time of each hoeing.

BRANFORD EXPERIMENTS.

In the raspberry field of A. E. Plant & Son, Branford, cabbage plants were set between the rows of berries during April, without treatment. The field was on a side hill sloping to the south and west. The rows used in the experiments were on the upper side, and extended north and south. The soil was rather heavy except at the north end of the rows.

On May 12th treatment was given as follows:

Rows 1 and 2 were left as checks, no treatment.

Rows 3 and 4, containing ninety-nine and one hundred and ten plants respectively, were supplied with tarred paper disks.

Row 5, check, no treatment.

Row 6, ninety-one plants, Row 7, ninety-four plants, and Row 8, ninety-nine plants, were treated with carbon disulphide applied through an oil can in a hole an inch from the plant and one and one-half inches deep. After the material was introduced into the hole, it was covered with soil by the foot. One pound of the liquid was used for the three rows.

The plants were examined on June 5th. and only two plants infested with the maggot were found, one in a check row and the other in a row treated with carbon disulphide.

VALUE OF TARRED PAPER DISKS.

Tarred paper disks and a tool for cutting them were first devised by Professor E. S. Goff of Wisconsin, and have since been used by Slingerland and others. They prevent (mechanically) the flies from laying their eggs at the base of the stem, and where made of tarred paper it is possible that the odor may have a repellent effect, though this is not certain.

In our tests these disks have given the best results of any form of treatment, and similar results have been obtained by other entomologists. It is important that they be applied before the eggs are laid, otherwise they are ineffective. Plants which have become badly injured by the maggot should be destroyed, those slightly damaged should be treated with carbon disulphide as herein described, and well fertilized to promote growth and vigor.

MAKING THE PAPER DISKS.

During the previous season the tarred paper disks could be purchased from a New York firm, but this season we were unable to obtain them. We did not have a special tool for cutting them, so they were made in the following manner:

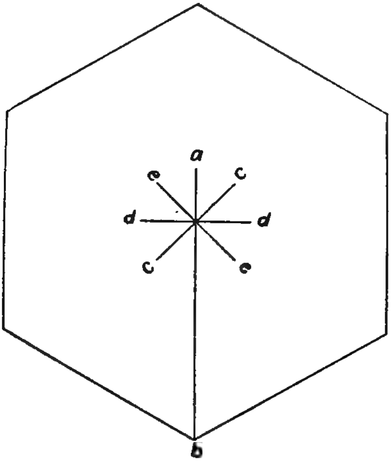

FIG. 19. Hexagonal disk of tarred paper for use on stems of cabbage plants.

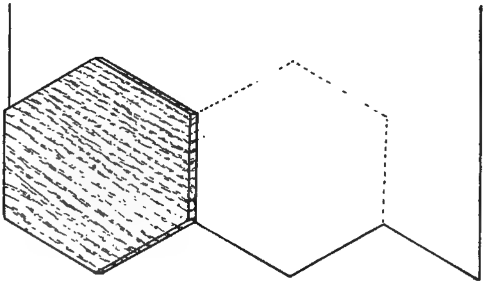

FIG. 20. Method of cutting hexagonal disks.

The disks were hexagonal in shape and four inches across, and were cut from a roll of single-ply tarred felt or paper. The paper was placed on a table and unrolled upon a smooth board as needed. A hexagonal form was made of wood one-quarter inch thick, with a tack through the center to prevent the form from slipping and to mark the center of each disk. The form being placed on the paper, a sharp knife was used to cut around it. A row of disks were cut from the full width of the paper and then stacked together, when the cut *a-b* (Figure 19) was made with the knife; *c, d* and *e* were made with a sharp chisel, which in this case was 1⅛ inches wide. After the first row has been cut, the paper will have an edge with regular points, which should be used to form two sides of the next row of disks.

Figure 20 shows the form placed to start another row of disks, and the dotted lines show that but three cuts are required to make each succeeding disk.

While this method would not be practicable for a large commercial grower, it will answer where but a few thousand disks are needed. They can be made at odd times during the winter and early spring. If made much in advance of the time when needed, however, they should be tightly wrapped and kept in a rather moist place so that the tar will not dry out and the disks become hard.

EXPERIENCES WITH HOME-MADE SOLUBLE OILS AND SOME OTHER SPRAY MIXTURES.

By W. E. Britton and B. H. Walden.

Probably the most important development in spraying for San José scale in 1907 was the working out of formulas for the preparation of home-made soluble or miscible oils, so that the orchardist can make them on his own place.

Professor Charles L. Penny, now of the Pennsylvania Station, but formerly chemist of the Delaware Station, has done much investigating along this line, and the results of his efforts were published in Bulletins No. 75 (June 18, 1906) and No. 79 (August 1, 1907) of the Delaware Station.

Mr. C. D. Jarvis, horticulturist of the Storrs (Conn.) Station, had also been working on soluble oils, and in Bulletin 49 (November, 1907) recommends a formula which he found best for general purposes.

The bulletins by Professor Penny explain the principles of making these mixtures and the rôle played by each of the ingredients, chiefly from the chemical standpoint. A large number of formulas are given, thus showing the possibilities of the subject, though one is recommended as being the best for the average orchardist to use. The bulletin by Mr. Jarvis gives brief directions to the orchardist about procuring materials and preparing the mixtures after a single formula, which is quite similar to the one recommended by Professor Penny, containing the same ingredients in only very slightly different proportions, except that the former contains crude oil where the latter has paraffine oil.

As many inquiries were made at this station regarding these mixtures, it was deemed best to make a practical trial of preparing and using them so that we might more intelligently answer the inquiries. Therefore, a kettle or feed cooker was purchased, and the materials were procured in barrel lots, consisting of carbolic acid, menhaden or fish oil, rosin oil, crude petroleum, paraffine oil, kerosene, and a small quantity of caustic potash. The first cost of these materials was nearly one hundred dollars, and of course some of them will last for a long time. The outfit is shown on Plate LVIII b. We had no particular trouble in making up the first lot according to directions, and care had been taken to purchase only the grade of materials recommended. But on using up the first barrel of paraffine oil, we ordered a second barrel of exactly the same oil, and it failed to emulsify as the other had done when used in the same quantities with the other ingredients. It was then necessary to try varying proportions of some of them, and Mr. Walden worked on it two whole days before we could use it in making a spraying mixture. A different grade of oil had been sold us for the same oil, and it required considerable experience to learn how to use it. Oil experts have informed us that the common trade names of oils are meaningless so far as their exact chemical composition is concerned, and that there is little assurance of being able to obtain the same thing twice unless it comes from the same well and is drawn at about the same time. It seems to us that the first cost of the materials, together with the uncertainty of obtaining uniform oils, make it impracticable for any except the larger orchardists to prepare their own soluble oils.

Orchard tests were also made. All fruit trees on the station grounds were sprayed January 23d. The mixture worked nicely, except that a thickened oily residue formed in the pump barrel and caused some trouble in clogging strainers and nozzles. This may have been due to an excess of rosin oil. The scale was kept well in check by the application, and no injury to the trees was noticed. Two barrels of this mixture, one made from crude and the other from paraffine oil, were furnished to Mr. F. H. Stadtmueller of Elmwood, who used it in April on rather large apple trees, applying it with a steam power sprayer. The residue was present in the tank, though not especially troublesome. The mixture was apparently effective in checking the scale and the owners were satisfied with the treatment.

A barrel of this mixture was used in the young apple orchard of A. E. Plant & Son of Branford, the spraying being done April 20th. An examination of this orchard December 10th showed that the trees are in good condition, and though most of them were only slightly infested at the time of treatment, it is now a difficult matter to find any living scales. Two or three trees which were badly infested two years ago showed but little live scale at this time.

Two barrels of the mixture made from crude oil were used in the apple and peach orchards of Mr. W. F. Griswold at Rocky Hill, in April. Mr. Griswold reported considerable trouble in using the material, and it did not seem to be very effective in holding the scale in check. Mr. Walden visited the orchard on December 2d and found the sprayed trees fully as scaly as those which were not treated. It is hard to explain why the treatment here was not more effective.

The trees on the station grounds were again sprayed with this material December 8th and 9th, 1908, and it worked satisfactorily, though the effect upon the trees and their scale insects cannot at this date be determined.

In all of the tests just mentioned the oil was mixed with water in the proportions of one part of oil to fifteen parts of water.

The cost of the materials actually used in making this home-made soluble oil was about twenty-one cents per gallon, not reckoning labor, the cost of the kettle, or interest on the money invested. Of course the cost would vary according to the fluctuating prices of the materials used.

This oil is now made by the Apothecaries Hall Company of Waterbury, and sold as "Victor Soluble Oil," in barrel lots, at thirty-five cents per gallon. It is also made by the J. T.

Robertson Company of Manchester, Conn., and sold as "Jarvis Spray Mixture" at thirty cents per gallon by the barrel.

OTHER OILS TRIED.

A five-gallon can of the soluble oil made by the Thomsen Chemical Company of Baltimore, Md., was used in the Plant orchard at Branford. It worked satisfactorily and the trees were clean in the fall.

"San-U-Zay" scale oil, made by J. T. Southwick of Rochester, N. Y., was also given a trial. This oil requires a solution of sal soda to make it emulsify, but it seemed to work nicely, and, like the preceding, kept the trees clean. Both of these oils were used in the same proportions as the home-made oils mentioned above.

Another kind of oil was sent us by Professor H. W. Hillyer of Farmington. This came in two parts; one, marked "B," was the oil preparation, and the other, marked "A," contained the emulsifier, together with a copper solution which was supposed to make it a fungicide. This was also used one part to fifteen parts of water, and four small scale-infested apple trees were thoroughly sprayed with it. When examined the first week in July, about twenty-five per cent. of the scales were alive. It is evident that this mixture should have been used in more concentrated form.

NEW PREPARED LIME AND SULPHUR WASHES.

Since our work with the lime and sulphur mixtures a few years ago (see Reports for 1903, p. 233; 1904, p. 221; 1905, p. 196; and 1906, p. 279) several prepared lime and sulphur washes have been placed upon the market. Some of these we have tested and a few gave good results, but most of them contained so much sediment that they did not spray readily, failed to destroy the scale, or else were so costly as to be prohibitive.

Recently there have been put upon the market a number of prepared lime and sulphur washes which are clear liquids, that is, entirely soluble, and contain no sediment to clog strainers and nozzles. Some of these are being sold at a price low enough so that orchardists are buying them to spray orchards of several thousand trees.

Three of these mixtures, in small quantities, have been tested by us:

"Lion Brand California Wash," a concentrated lime, sulphur and salt mixture, made by the James A. Blanchard Company of New York. On April 19th four small apple trees were thoroughly sprayed with this mixture, following directions. The first week in July the trees were examined, and only 3.8 per cent. of the insects found to be alive.

"Swift's Concentrated Sulphur-Lime," made by the Merrimac Chemical Company of Boston, and "Sulfocide," made by the B. G. Pratt Company of New York, have each been tried on a few trees, but it is now too early to be certain of the results.

Of course these preparations must be tested on a large scale and under varying conditions before we can recommend them, but there still seems to be a demand for lime-sulphur washes, and if they can be made cheaply and satisfactorily, most of the smaller growers will prefer to purchase the prepared mixture.

CONCLUSIONS.

Our own experience in making soluble oils leads us to advise orchardists to purchase a prepared mixture, except that in some cases a large grower might find it profitable to buy the materials and make it at home. Materials left over will keep for a time, but do not improve, and some loss takes place through leakage and evaporation. It is also certain that where made in large quantities the product will run more uniform than it is possible to make it in small quantities, even with great care.

It is not claimed that any of these home-made oils are better than the best kinds on the market—they are simply cheaper and can be used for the purpose.

It is probable that soluble oils will continue to be used for spraying apple orchards, especially large trees, where it is difficult to coat the pubescent twigs with a lime-sulphur wash, and to reach the scale insects under the edges of the rough bark and the bud scales. They are also much to be preferred for use in the city garden, the public park and the nursery.

On the other hand, soluble oils have not entirely superseded lime-sulphur. Several orchardists have continued using the latter, and some others are going back to it. The lime-sulphur wash is certainly an effective scale destroyer on smooth-barked trees, and no better treatment is known for the peach orchard than to spray it in the spring with the lime-sulphur wash, which is an excellent fungicide and a good preventive of leaf-curl.

INSECT NOTES.

Snow-White Linden Moth Abundant. On July 8th the Associated Press and several New Haven newspapers telephoned to the entomologist's office regarding the reported occurrence of the brown-tail moth in Woodstock, where some newspaper correspondent had reported it as being abundant and swarming around the street lights. Through telephone and written communication with several reliable men in that part of the state, including Mr. L. H. Healey, Master of the State Grange, this report could not be verified and specimens could not be obtained.

A few days later the New York papers told about a pure white moth that swarmed about the electric lights in New York and Brooklyn. On July 19th a similar swarm of white moths appeared in New Haven, and the description was a feature of the newspapers the following day. These moths were present for about two days, then disappeared, but were very abundant while they lasted, and may be the same species as that reported from Woodstock. This moth is called the snow-white linden moth (*Ennomos subsignarius* Hübn.), and in some books is mentioned under the name of elm span worm. It feeds upon a variety of forest and shade trees, and is reported as causing much damage to beech trees in New York State in 1907,* though linden, elm, maple, chestnut and horse chestnut are often damaged.

This moth is pure white, has a wing expanse of about one and one-half inches and is shown on Plate LIX a. It is frail, with angulated wings, and belongs to the moth family Geometridæ, the larvæ of which are measuring worms or loopers. There is one generation each year, and both sexes have wings. Spraying the foliage with arsenical poison is about the only remedy.

Hickory Tussock Caterpillars Killed by a Fungus. In the Report for 1907 there is a short article about the hickory tussock moth, *Halisidota caryæ* Harris, and its abundance in Connecticut during the past two years. It was also very abundant in the summer of 1908 and did some damage to various kinds of trees, but in September and October many dead caterpillars were observed adhering to the trunks and branches of trees and sometimes on fences and stone walls. These had been killed by a fungus which, according to Dr. Clinton, has been studied and named in manuscript by Professor Roland Thaxter of Harvard University, but the description and name have not yet been published. From the number of dead caterpillars seen while inspecting nurseries about the state, this fungus must be regarded as an important natural enemy of the species. In some cases a dozen of these dead caterpillars would be found on the base of the trunk of a single tree, and there were probably many more on the branches. The appearance of a fungus-killed caterpillar may be seen on Plate LIX b. Other species of caterpillars, notably *H. tessellaris* and probably *Estigmene acræa,* were killed in a similar manner by this or some other agency, though only a few of them were found.

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* Twenty-third Report of N. Y. State Entomologist for 1907, p. 23.

Lead Arsenate vs. Paris Green for Spraying Potatoes. In the experimental field at Mt. Carmel, Doctors Clinton and East of this station have each year grown three or more acres of potatoes. During 1908 they made arrangements with the writer to take charge of the first sprayings to kill the Colorado beetle, before it was time to use Bordeaux mixture. Little damage was done, so the first treatment was given June 22d. On two plats of one acre each on the northwest corner of the field, conditions were practically uniform as regards the plants and their infestation. Here and there throughout, certain hills were badly eaten, though most of the plants had not been injured. The acre plat nearest the road was treated with Paris green, one-half pound in fifty gallons of water, and two pounds of lime added. The plat adjoining this on the east was sprayed the same day with lead arsenate, three pounds in fifty gallons of water. Both poisons were used upon the third acre. A hard shower came the next day. On June 27th, four days after the treatment, the potatoes were examined and the fewest larvæ were found on the field sprayed with lead arsenate, while no injury to the plants could be detected. Where Paris green was used, not only were the larvæ more abundant, but in spite of the fact that plenty of lime was used, there was some injury to the plants, shown by many leaves and tips of leaves becoming dry and dead a few days after the treatment. The poison was applied with the Niagara gas sprayer, covering four rows at once, as shown on Plate LVIII a. This sprayer does not have a satisfactory arrangement for agitating the liquid, but in most other respects it is fairly satisfactory.

The Three-Lined Leaf-Beetle on Potatoes. This insect was more than usually abundant on potatoes and in some cases did almost as much injury as the Colorado beetle, to which it is closely related, both belonging to the family *Chrysomelidæ.* The three-lined leaf-beetle, *Lema trilineata* Oliv., is of a pale yellow color, with three black longitudinal stripes on the back, and it resembles the striped cucumber beetle, though larger. It deposits yellow eggs in rows along the mid-rib on the under sides of the leaves. The larvæ are yellow and have the disgusting habit of covering themselves with their own excrement. There are two broods each year. The damage is similar to that caused by the Colorado beetle and the same remedies are to be advised. Larvæ of the three-lined leaf beetle were brought to the station on July 12th, with two other kinds of beetles which had been observed feeding upon them in New Haven. The predaceous beetles were *Lebia grandis* Hentz. and *Pterostichus lucublandus* Say, both common species of the family *Carabidæ.*

Leaf-Beetles Devouring Marsh Golden-Rod. During a collecting trip to the Stratford marsh, July 21st, it was noticed that the golden-rod (*Solidago sempervirens*) which grows in bunches commonly about the marsh was being eaten up by insects. On closer examination, two forms of injury were apparent and caused by two different kinds of beetles of the family *Chrysomelidæ.* The larger, *Trirhabda canadensis* Kirby, is dull yellow, with three blackish longitudinal stripes, and is about three-eighths of an inch in length. It feeds upon this golden-rod in both the larval and adult stages, and the plants were stripped of their topmost leaves and tender shoots by this insect. The lower leaves were less injured and were still green. In other clumps the leaves were entirely brown, many of them being rolled and containing large numbers of a beetle known as *Microrophala vittata* Fabr. This beetle is one-fourth of an inch long, with the entire upper surface of the body pitted and striped longitudinally with dull red and blue. The larvæ are said to be miners in the leaves of this golden-rod. As the host plant is something of a nuisance to growers of salt marsh hay, perhaps these insects may be regarded as beneficial.

Chrysomelid Beetle Damaging Young Chestnut Trees. On June 10th specimens were received from Dr. Robert T. Morris of New York, who raises nuts on his summer place at Stamford, Conn. Small metallic green beetles a trifle over one-eighth of an inch in length were devouring the leaves and young shoots of choice young chestnut trees of the Japanese species (*Castanea Japonica*), threatening their destruction. The beetles had the habit of dropping from the leaves or flying away when disturbed. It was finally necessary to resort to spraying with Paris green in order to destroy them. The species proved to be *Nodonota puncticollis* Say.

New York Weevil Injuring Pear. On May 26th it was reported that an insect was injuring young pear trees in the orchard of W. A. Henry & Son at Wallingford. Mr. Walden visited the orchard and found that the New York weevil, *Ithycerus noveboracensis* Först, was the depredator. The adults were eating into the twigs at the base of the new growth, in some cases nearly severing it. There were from one to three on each tree, and on some of the newly-set trees the new growth had all been destroyed. The injury was confined mostly to the pears, though one plum tree showed the attacks of this insect.

The New York weevil is a beetle of the family *Curculionidæ*, commonly called "snout beetles" because the head is prolonged forward into a beak or snout, on the end of which the mandibles or jaws are located. In color it is gray or slightly reddish, with whitish, closely appressed pubescence arranged in rows lengthwise the body. It is marked with a number of small quadrate black spots, is from one-half to five-eighths of an inch long, and is shown on Plate LIX c.

The owners sprayed the trees with lead arsenate, and thought that it proved effective, as the beetles soon disappeared. As a rule, the beetles of this family are hard to kill with poisons, and hand picking is therefore advisable on small trees. Normally this beetle breeds in oak, beech and hickory twigs, and possibly visited the pear trees from the neighboring woodland. It has also been known to attack peach.

Snout Beetle Injuring Greenhouse Plants. On April 6th, beetles were received from Litchfield, where they had been eating the leaves of palms, lemon tree, *Tradescantia* and *Dracæna.* It proved to be *Otiorhyncus sulcatus* Fabr.

Strawberry Weevil. On June 3d specimens of the strawberry weevil, *Anthonomus signatus* Say were received from South Killingly and from Huntington, where at both places the stems of the buds and developing fruit had been eaten by the weevils. This insect is a snout beetle of the family *Curculionidæ,* and is less than one-eighth of an inch long and brown or black, with white markings.

The injury is caused by the female, which lays an egg in the bud just before it opens, then crawls down the pedicel and cuts it partly off, so that it fails to develop and later becomes separated and falls to the ground. The growing larva feeds upon the pollen inside of the bud, which after falling to the ground is kept moist and in a condition favorable to the development of the larvæ, which reach their full size in about three or four weeks.

The strawberry weevil when abundant is a difficult pest to control, and arsenical sprays are not very satisfactory. Pistillate varieties are not attacked, and growers are advised to grow only enough staminate plants for purposes of fertilization. Clean culture is also to be recommended.

Raspberry Sawfly. The raspberry sawfly, *Monophadnoides rubi* Harris, was present in a number of berry patches around New Haven, and was sent in from Stonington on July 8th. The larvæ are nearly three-quarters of an inch long when fully grown, dark green in color, and covered with lighter green forked spines. They devour the leaves of raspberry and blackberry, usually being found upon the upper surface. The eggs are white and are laid in the tissues of the leaf. The adult is a four-winged fly with a black thorax and dark reddish abdomen. Spraying with arsenites, or even with fresh hellebore, may be practiced as a remedy.

Leaf-Folder Injuring Apple. In many parts of the state apple trees were considerably damaged by a small larva which fed upon the leaves and folded and fastened the edges together. At Stonington this pest seemed to be more injurious than around New Haven. Though we did not obtain the adults, it was doubtless the apple leaf-folder, *Ancylus nubeculana* Clem., a small moth of the family *Tortricidæ,* having a wing-spread of about five-eighths of an inch, and brown and white in color. Ordinarily this insect is not troublesome, but was injurious enough at Stonington to warrant spraying. Lead arsenate is advisable for this.

Leopard Moth in Connecticut. This insect in its larval stage is one of the worst pests of shade trees in the vicinity of New York City, boring in the twigs and branches, the symptoms being dead limbs projecting above the leafy branches. The leopard moth, *Zeuzera pyrina* Fabr., was introduced probably by accident from Europe, and first noticed in this country near New York about 1882. Since then it has been spreading northward, but was not known to have reached Connecticut until July 1st, 1907, when Professor H. W. Foote captured in New Haven two specimens, which are now in the station collection. This insect is also serious in the vicinity of Boston. The adult has a wing expanse of about one and one-half inches, the wings being whitish or transparent, marked with a large number of small dark gray or black dots. The body is nearly black.

Infested branches will often wilt, and can be cut away and destroyed before the borers escape. Carbon disulphide may be injected into the burrows, and the opening stopped with clay, hard soap or putty, to kill the larvæ.

Appearance of Corn Ear-Worm or Boll-Worm, Heliothis obsoleta Fabr. Some larvæ and their work were brought to the station from Bethany on October 28th. The writer saw this insect in New Haven some twelve or thirteen years ago, but has never happened to see it since. The larva attacks corn, eating the unripe kernels at the tip of the ear, also tomato, cotton, and several other cultivated plants, though in the Northern States it is not a very serious pest. The adult is dull yellow, with dark markings, and the larva appears in a variety of colors, such as green, brown, pink and purple. About the only preventive measure necessary is to plant the corn earlier, so that it will ripen before October.

Abundance of the Pyramidal Caterpillar, Pyrophila pyramidoides Guen. This caterpillar is about one and one-half inches long, green, with a yellowish stripe along each side and a whitish stripe along the back, head whitish, mandibles tipped with black. The last segment is thickened dorsally, making almost a right angle.

In the writer's garden these caterpillars fed upon the new leaves and shoots of the pear trees and also attacked roses. Specimens received from Warren on June 12th had been eating pear, rose and quince. They were also found on *Rosa rugosa* on the station grounds.

The adult is a noctuid moth having a wing expanse of nearly two inches. The front wings are dark brown marked with lines and dots of paler brown and white. The rear wings are lustrous and of copper red color.

A New Forest Pest in Northern New England. During the past two years the caterpillars of a moth, *Heterocampa guttivitta* Walk., have damaged forests in Maine, New Hampshire and New York. In 1907 in the state of Maine much of the forest growth over large areas for a distance of forty miles was stripped, according to Miss Edith M. Patch,* entomologist of the Maine Station. According to Dr. E. P. Felt,† state entomologist of New York, this same insect appeared in that state in 1907. The same species denuded thousands of acres of hard wood trees in the White Mountain region of New Hampshire in 1908, and Director E. D. Sanderson of the New Hampshire Station issued a press bulletin regarding the matter. It is during July and August that the defoliation becomes noticeable, and several different kinds of trees are attacked, though the caterpillars seem to prefer beech, maple and apple foliage.

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* Bulletin 148, Maine Agr. Expt. Station, p. 262, 1907.

† Twenty-third Report of N. Y. State Entomologist for 1907, p. 21.

a.—Scraping apple trees.

b.—Spraying infested spruce trees with lead arsenate.

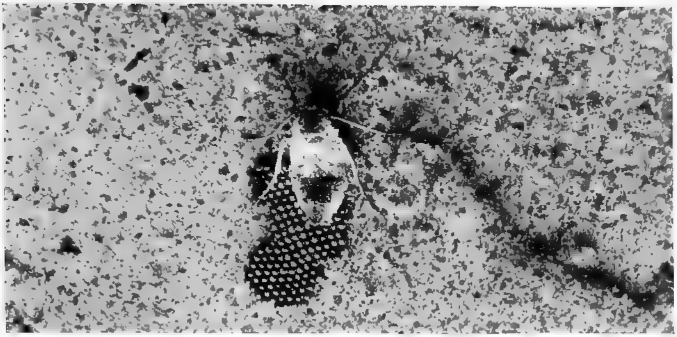
GYPSY MOTH WORK AT STONINGTON.

a.—View in a back-yard after cutting and burning infested weeds.

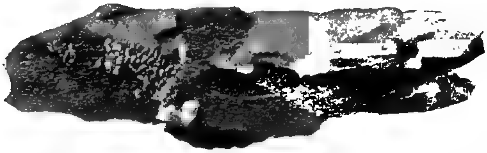
b.—A clump of wild roses growing on this spot contained 275 caterpillars.

GYPSY MOTH WORK AT STONINGTON.

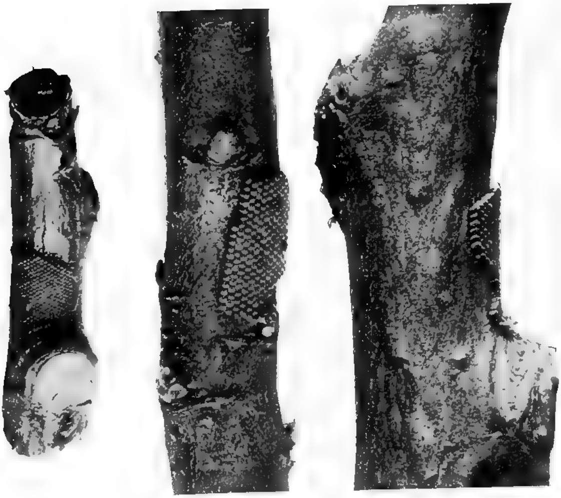
PLATE XLIV.



a.—Adult female and egg-mass of the fall canker-worm. Twice natural size.



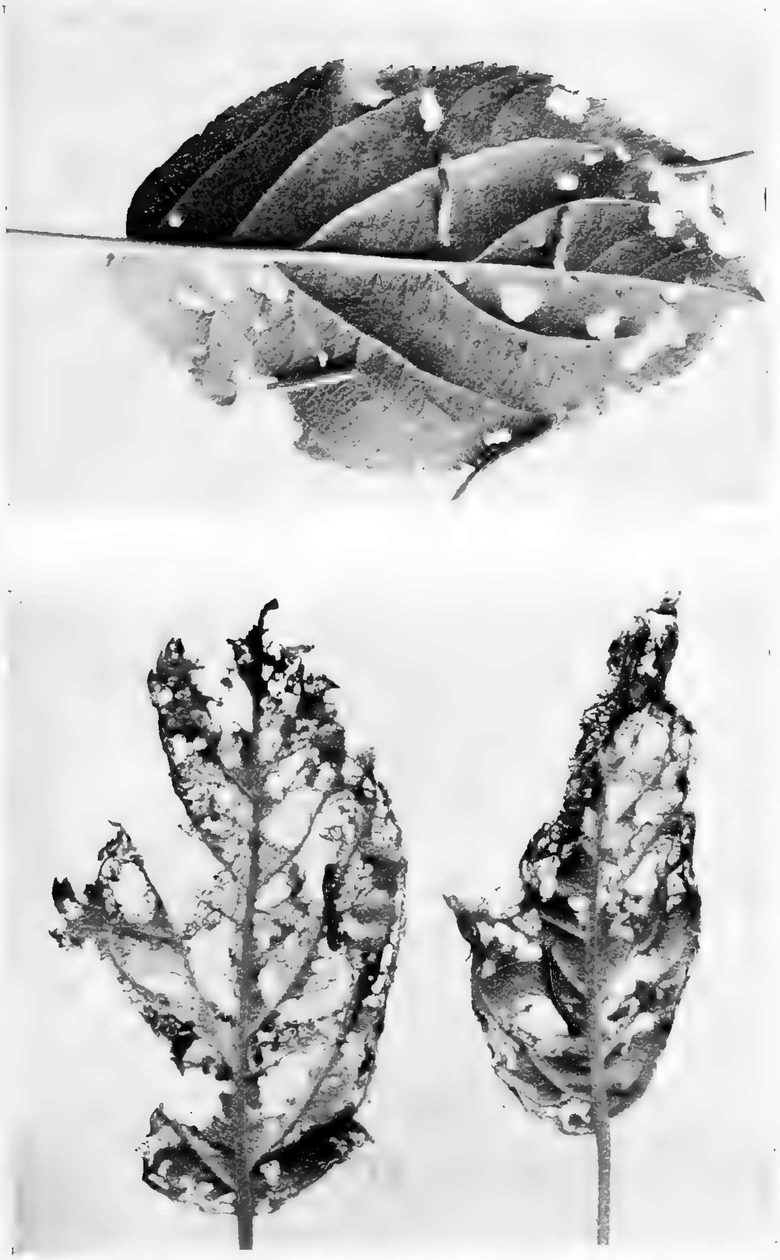
b.—Eggs of the spring canker-worm. Twice natural size.



c.—Egg-masses of the fall canker-worm. Natural size at left, others twice natural size.

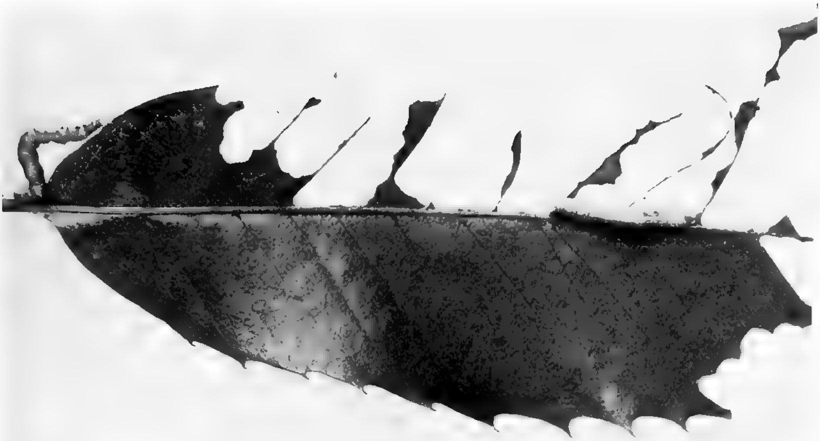
CANKER-WORMS.

PLATE XLV.

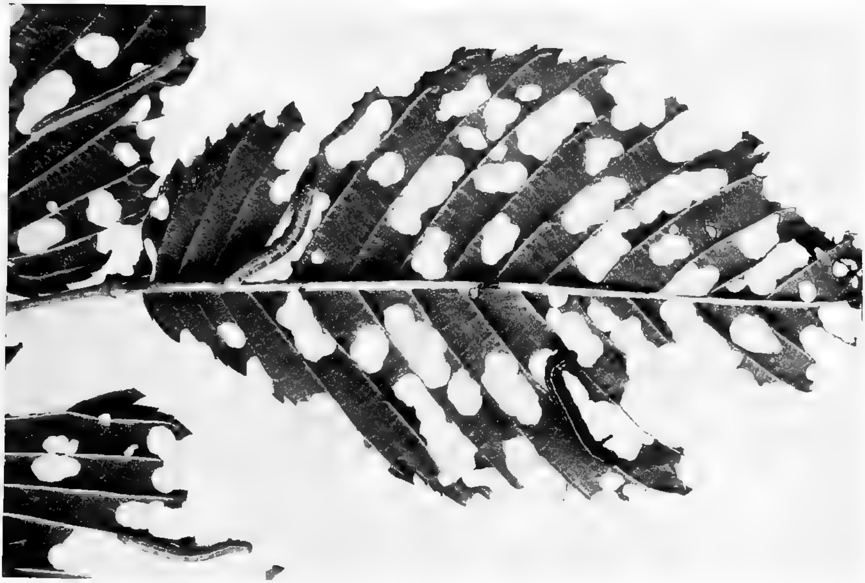


FALL CANKER-WORMS FEEDING ON APPLE. Both natural size.

PLATE XLVI.



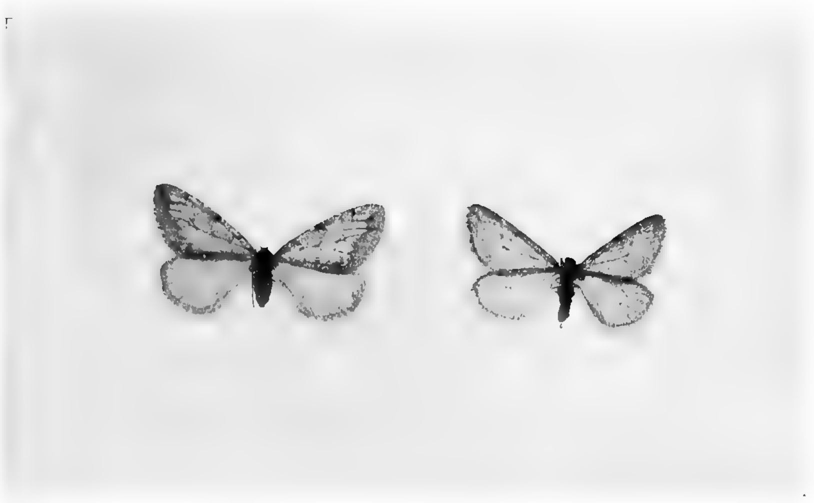
a.—Feeding upon chestnut. Natural size.



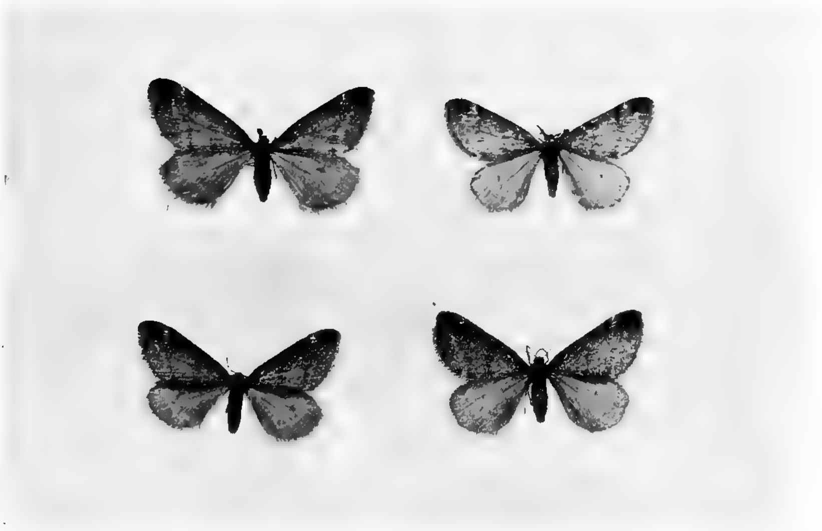
b.—Feeding upon elm. Natural size.

FALL CANKER-WORMS AND THEIR WORK.

PLATE XLVII.

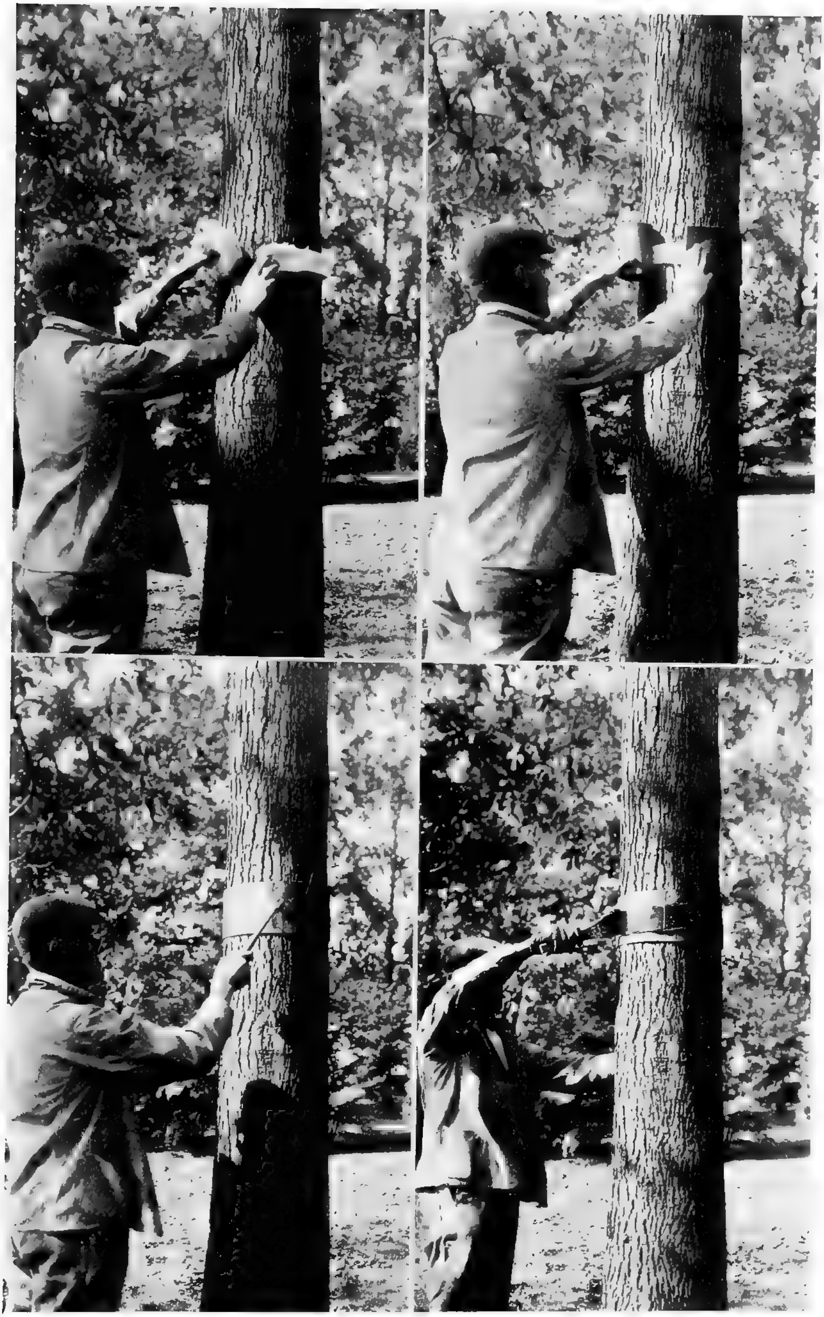


a.—Adult males of the spring canker-worm.



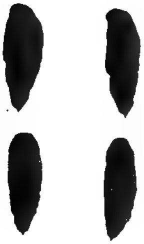
b—Adult males of the fall canker-worm.

MALE CANKER-WORM MOTHS. All natural size.

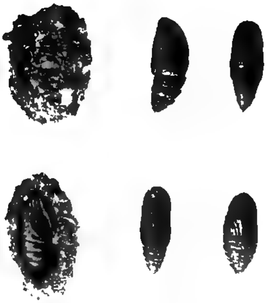


METHOD OF APPLYING STICKY BANDS TO PROTECT TREES FROM CANKER-WORMS.

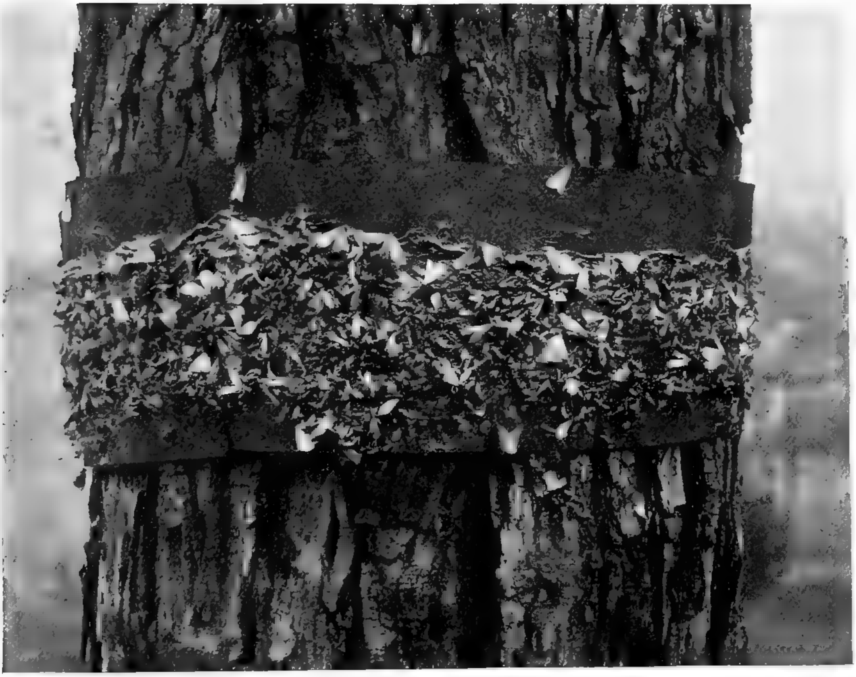
PLATE XLIX.



a.—Pupae of the spring canker-worm. Twice natural size.

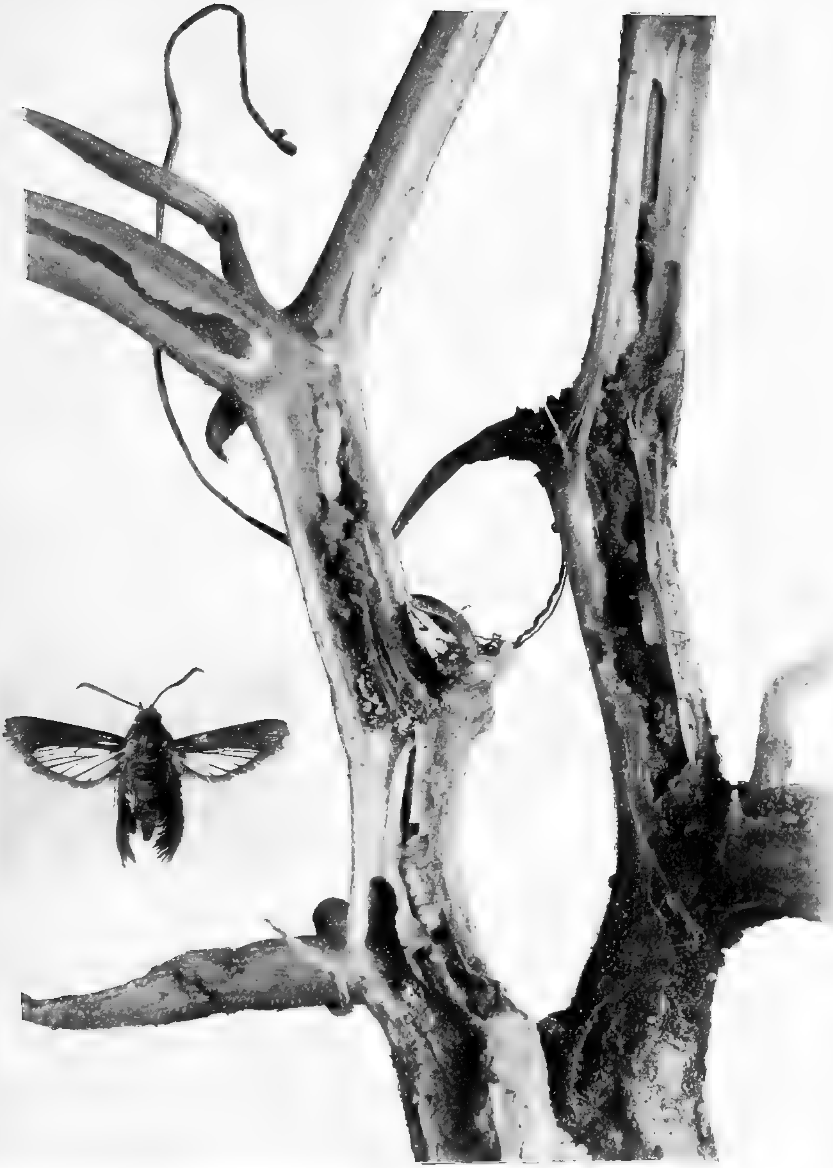


b.—Cocoons and pupae of the fall canker-worm. Twice natural size.



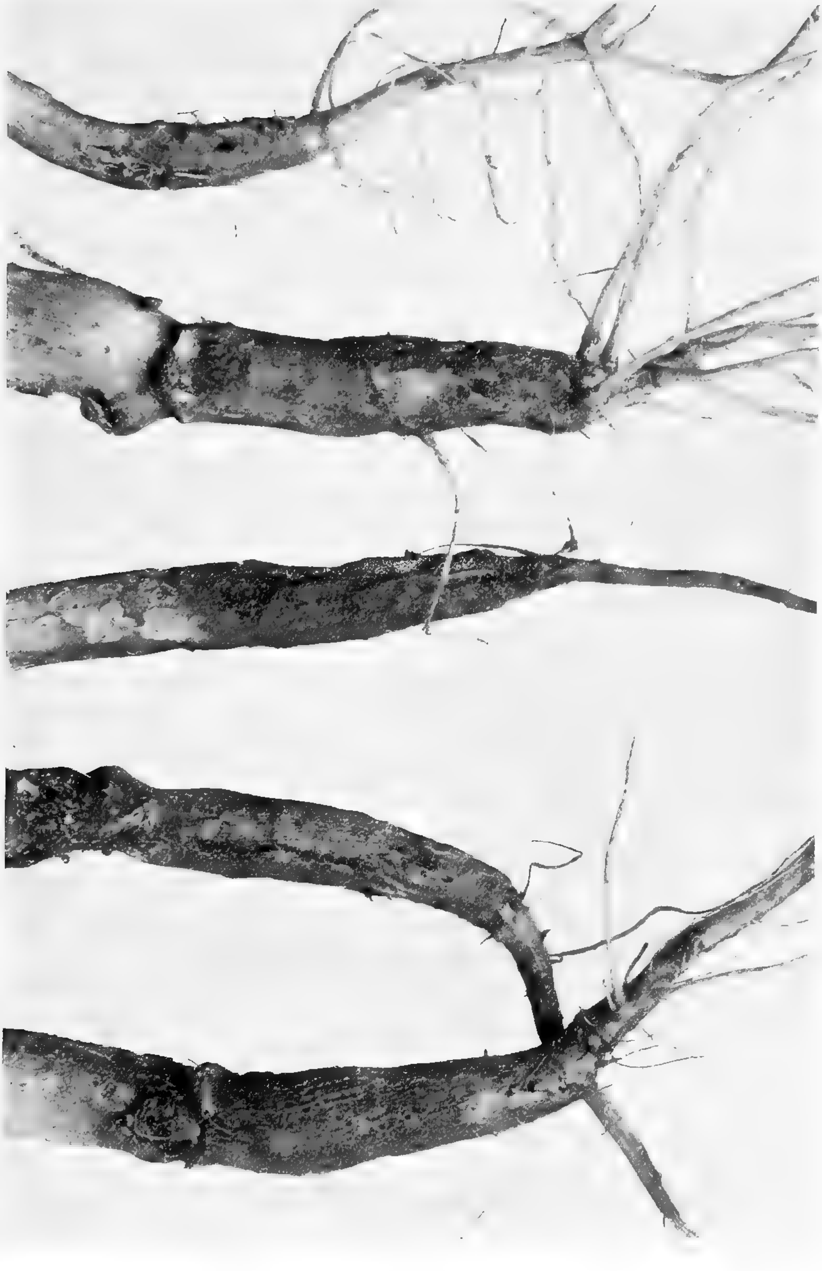
c.—Adult male and female moths, and egg-masses on sticky band.

CANKER-WORM COCOONS AND ADULTS.



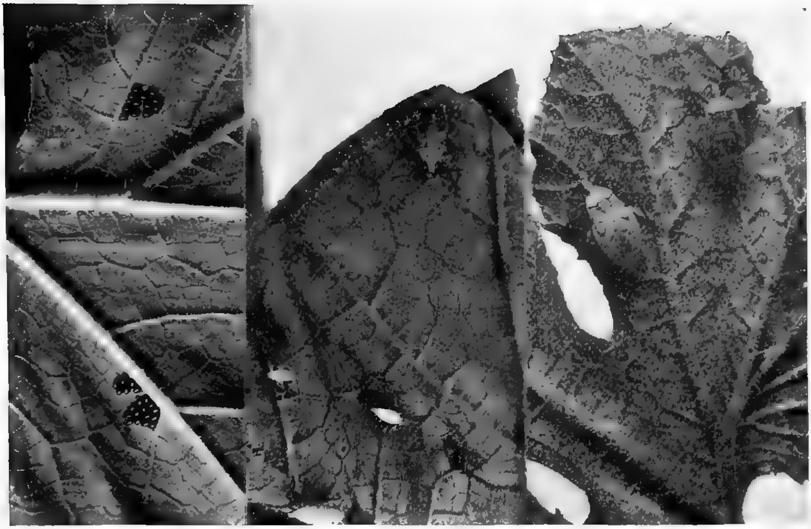
SQUASH BORER: ADULT AND WORK OF LARVAE IN SQUASH STEMS.

Slightly enlarged.

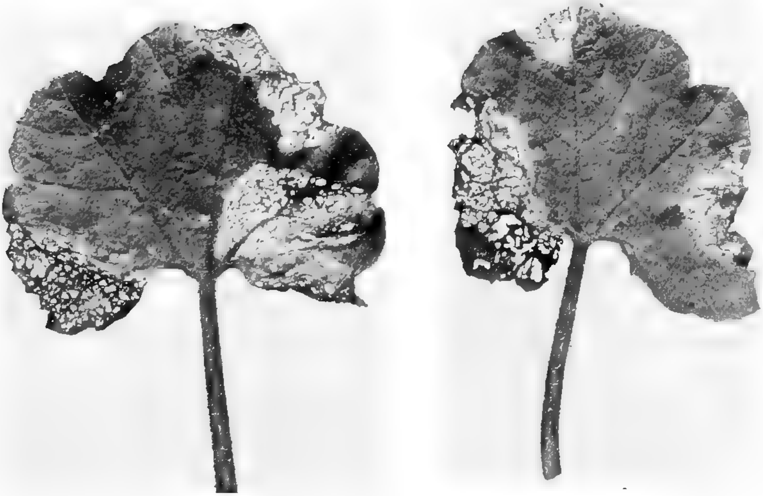


CUCUMBER PLANTS INJURED BY THE LARVAE OF THE STRIPED BEETLE.
Natural size.

PLATE LII.



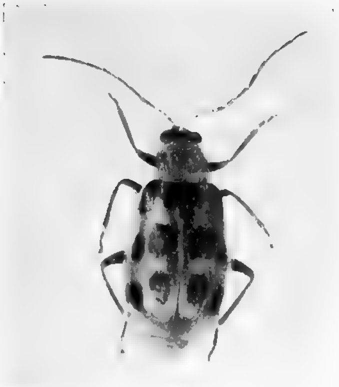
a.—Eggs and young squash bugs. All natural size.



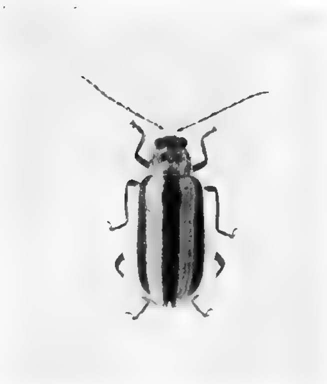
b.—Work of the squash lady-beetle. Greatly reduced.

SQUASH BUG AND WORK OF SQUASH LADY-BEETLE.

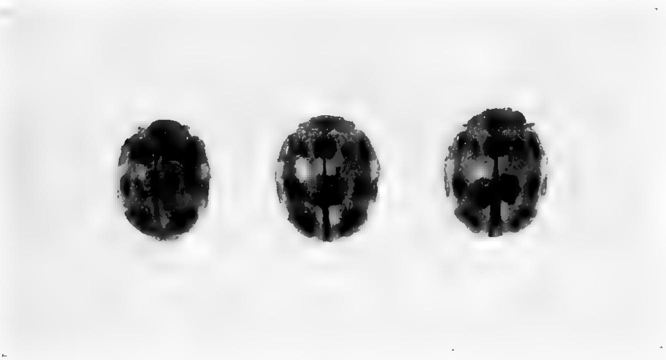
PLATE LIII.



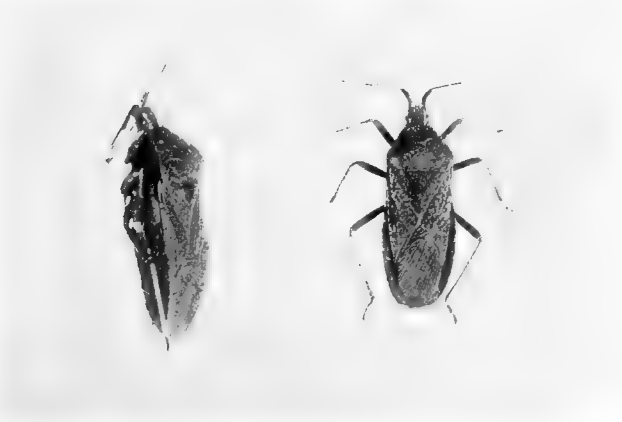
a.—Twelve-spotted cucumber beetle. Enlarged four times.



b.—Striped cucumber beetle. Enlarged four times.

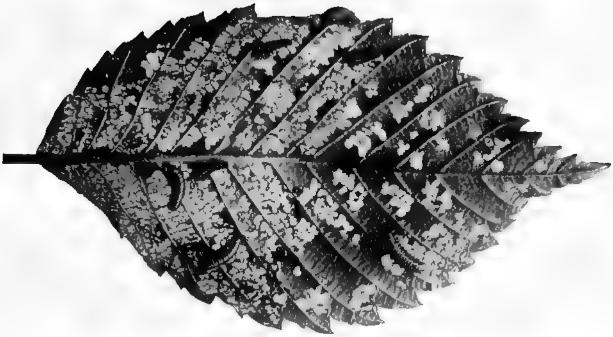


c.—Squash lady-beetle. Twice natural size.

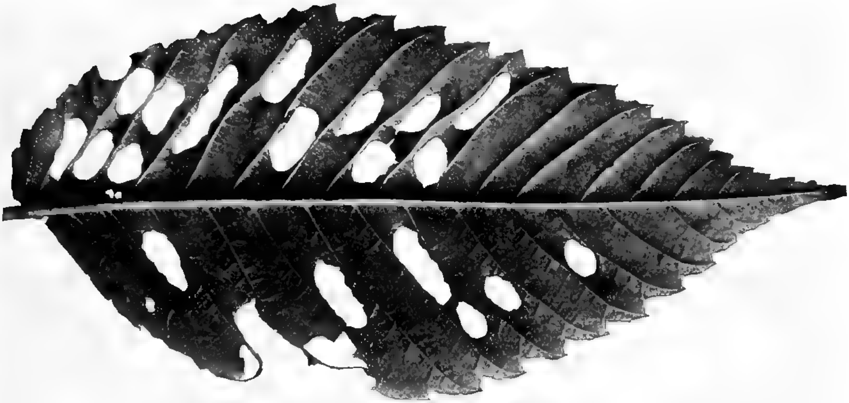


d.—Squash bug. Twice natural size..

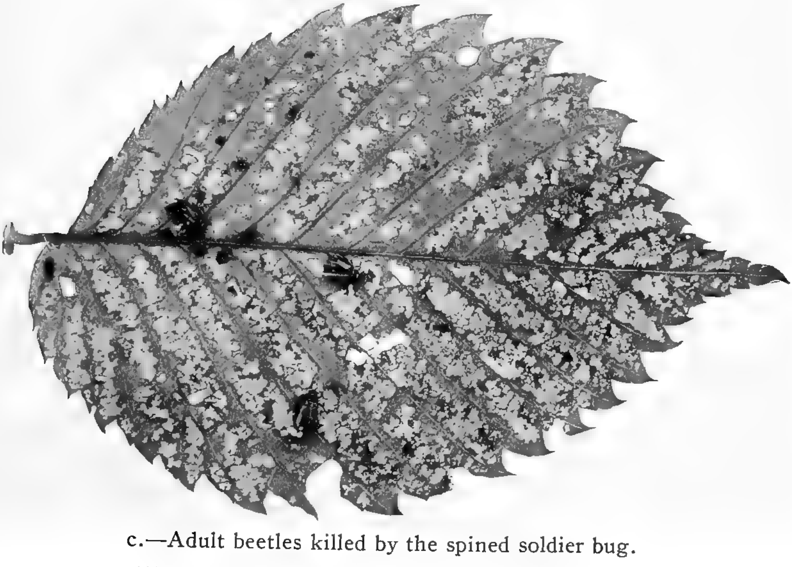
SQUASH AND CUCUMBER BEETLES AND THE SQUASH BUG.



a.—Larvae and their work.



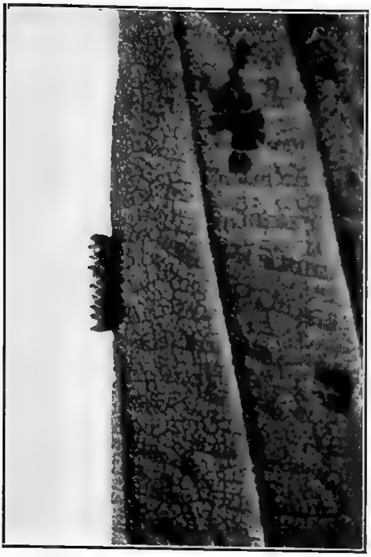
b.—Holes eaten by adult beetles.



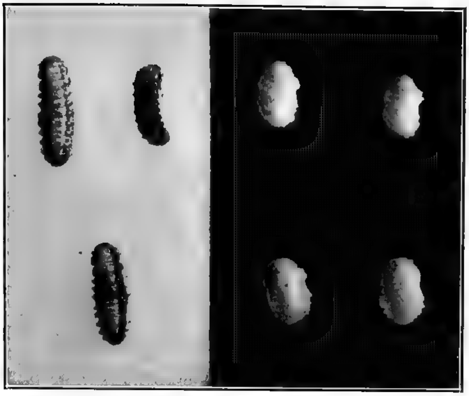
c.—Adult beetles killed by the spined soldier bug.

WORK OF ELM LEAF-BEETLE. All natural size.

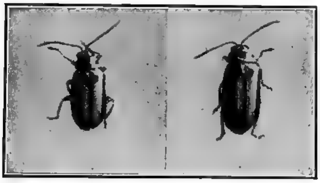
PLATE LV.



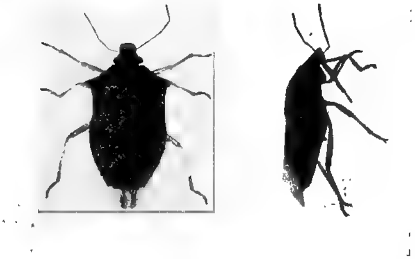
a.—Cluster of eggs; greatly enlarged.



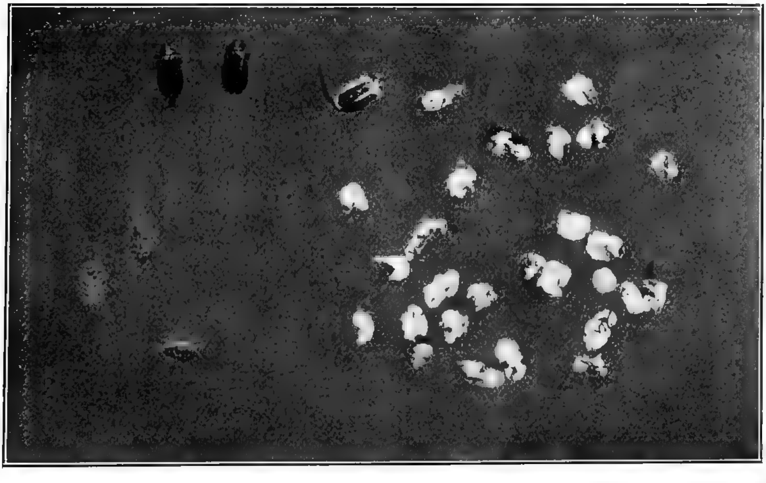
b.—Larvae and pupae; twice natural size.



c.—Adult beetles; twice natural size.



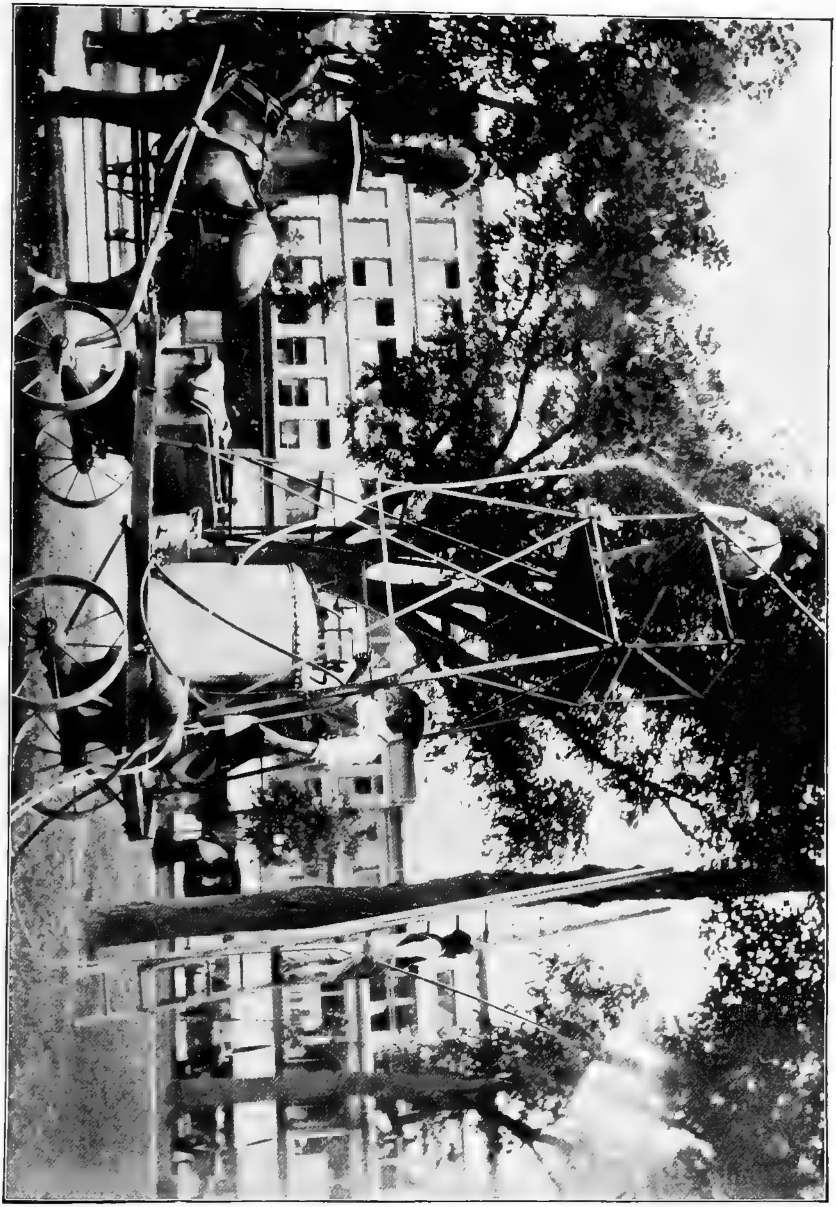
d.—The spined soldier bug, *Podisus maculiventris*, Say. Twice natural size.



e.—Pupae and adults killed by fungus. Healthy specimens at the left, natural size.

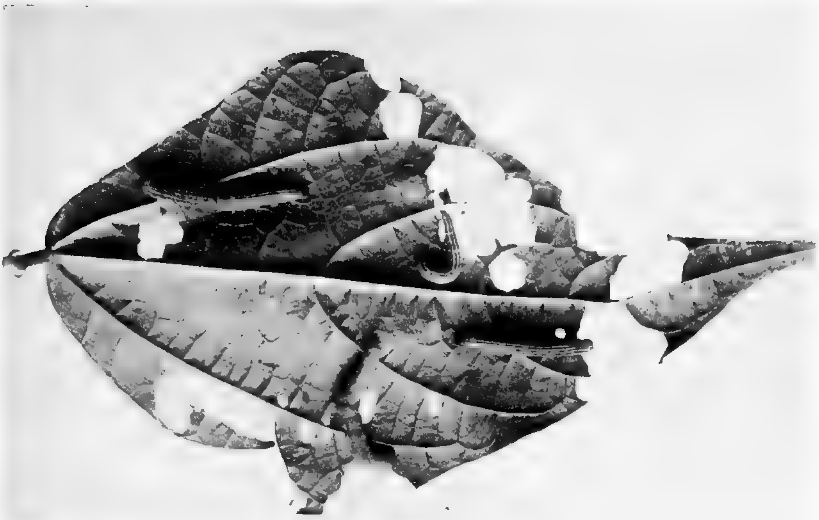
THE ELM LEAF-BEETLE.

PLATE LVI.

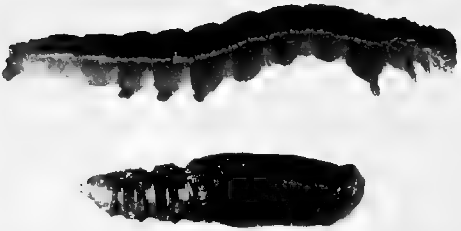


"NIAGARA GAS SPRAYER" AND OUTFIT FOR SPRAYING STREET TREES. (After Smith, Rep. N. J. Expt. Sta., 1905.)

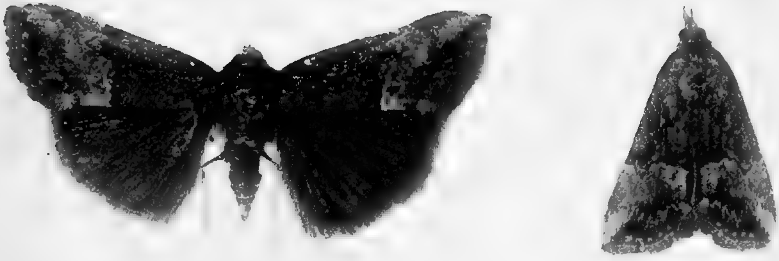
PLATE LVII.



a.—Larvae feeding upon bean. Natural size.



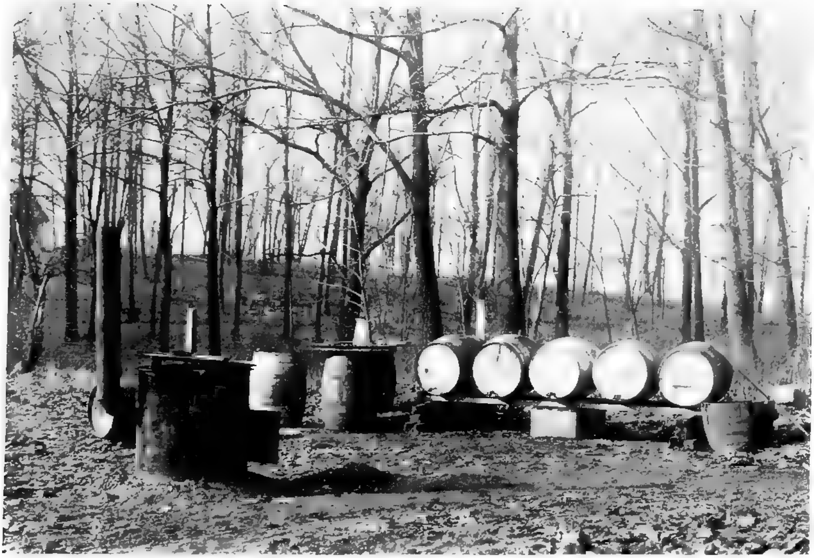
b.—Larvae and pupa. More than twice natural size.



c.—Adult moths. Twice natural size.

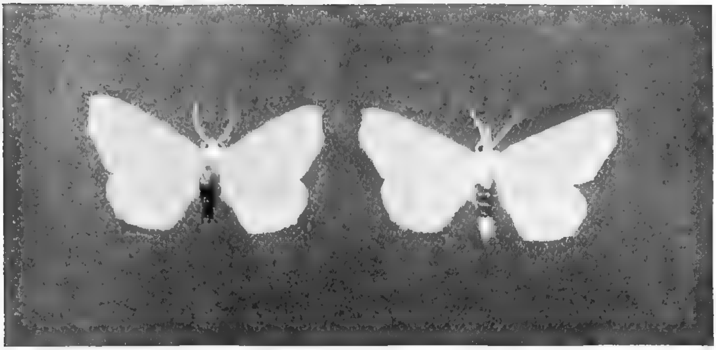
GREEN CLOVER WORM.

a.—Applying lead arsenate to potatoes.



b.—Outfit for making soluble oil.

SPRAYING POTATOES: OUTFIT FOR MAKING SOLUBLE OIL.



a.—Snow-white Linden moth. Natural size.

b.—Hickory tussock caterpillar killed by a fungus. Twice natural size.

c.—New York weevil. Twice natural size.

LINDEN MOTH: PARASITIZED CATERPILLAR: NEW YORK WEEVIL.

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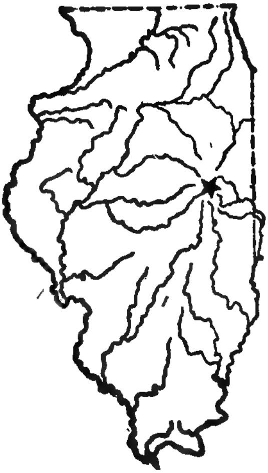
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 116

ON THE LIFE HISTORY, HABITS, AND ECONOMIC RELATIONS OF THE WHITE-GRUBS AND MAY-BEETLES

By S. A. FORBES
State Entomologist



URBANA, ILLINOIS, AUGUST, 1907

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ON THE LIFE HISTORY, HABITS, AND ECONOMIC RELATIONS OF THE WHITE-GRUBS AND MAY-BEETLES (*LACHNOSTERNA*).

The insects generally known as white-grubs are the young, or larvæ, of the large brown beetles commonly called "June-bugs" or May-beetles. For a practical knowledge of these destructive insects it is necessary that we should know the various species of them which do serious injury to agricultural and to horticultural crops; the life histories of all these species; their relative numbers in different parts of the state in different years and in different periods of years; their food, both as grubs and as adult beetles, including their common preferences where several kinds of food are available to them; their significant habits, especially those of reproduction; their relations to variety of weather and to seasonal change; their modes, times, and places of hibernation; the range of their daily movements and of their movements of migration and dispersal; their enemies, their diseases—especially those of a contagious character, and the other natural checks on their multiplication; their relation to varieties of soil, to its physical condition, its moisture, and its exposure to the sun; their relation to varieties of the subsoil also; the effects on their continuance and increase, of various agricultural operations and kinds of farm management; and their own effects, under varying conditions, on the several kinds of crops subject to injury by them. Finally, the whole field of preventive and remedial measures of a more or less artificial character must be thoroughly explored, including the results of practical experiments on the scale of actual farm management.

The subject is made especially difficult and complicated by several facts and circumstances. There are many species of these insects recognizable in the beetle stage but seemingly not distinguishable as larvæ; hence one frequently can not tell what kind of grub he is dealing with until he has reared specimens to the adult. The life history of these insects has a prolonged cycle, probably of three years, but just how many is not definitely known, and life histories can be completed only by keeping specimens alive, under more or less artificial conditions, for this entire time. The various species differ sufficiently in certain parts of their life histories to make it necessary to follow each out separately; and it is not impossible that important differences may be found due to differences in latitude and climate, between northern and southern Illinois; hence each species must be studied in different parts of the state. The most important species—that is the most abundant ones—are not the same in all parts of Illinois, and the relative importance of the various species must be made out for each region separately. The unexplained sudden disappearance, several times noticed by us, of nearly the whole grub population of badly infested fields before their transformation to the pupa, suggests the occurrence among these insects of contagious diseases—a supposition borne out by several field and insectary observations; and the whole subject of their bacterial and other fungus parasites consequently invites attention. The enormous effect of the rapid multiplication, under favorable conditions, of certain insect parasites—a hymenopterous enemy, *Tiphia inornata,* especially—requires a critical and complete study of the life history of these parasitic insects also, especially as there is some probability that we shall be able to increase their efficiency by artificial measures.

No one has heretofore undertaken to work out to a finish this difficult but highly important economic problem, and our present knowledge of the white-grubs is a patchwork of fragments, contributed by a considerable number of observers working on various species and in different parts of the country. The nearest approach thus far made to a continuous investigation of the subject was carried on in this office in the years of 1886–1890, and its results were published in 1891 in Volume III. of "Insect Life."*

They were also incorporated, with some later studies, in the Eighteenth Report of the Illinois State Entomologist, printed in 1894. In the year 1906 I finally began what I now hope may prove to be a steady and comprehensive study of this problem for the state of Illinois; and I have now to report some of the first results of this work, which I have incorporated, however, with other data and conclusions in a way to give us a fairly full synopsis of the present state of our knowledge, and a clear view, consequently, of its deficiencies.

THE ECONOMIC SPECIES.

The kinds of white-grubs common enough in Illinois to attract attention because of their injuries, belong, so far as we now know, to nine species, although it is likely that this list would be longer if the injurious grubs of southern Illinois were as well known to us as those of the central part of the state. Besides these nine injurious grubs, there are three other very abundant kinds which resemble closely the injurious species, although they are themselves harmless in the grub stage.

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*"On the Life History of the White-grubs." By S. A. Forbes. Insect Life, Vol. III., No. 5, pp. 239-245.

Eight of the species known to be injurious belong to the genus *Lachnosterna* and one to the genus *Cyclocephala.* Of the abundant but harmless grubs, one, frequently called the muck-worm because it lives in stable manure, is known to science as *Ligyrus relictus*; another, called the carrot-beetle in the adult stage, is *L. gibbosa*; and the third is the larva of the green June-bug of southern Illinois and of the Southern States generally, known in the beetle stage as *Allorhina nitida.* All the last three species are injurious as beetles, but only one of them, the larva of the carrot-beetle, is at all injurious as a grub, and then only slightly or occasionally so. The eight species of *Lachnosterna* known to be injurious in Illinois are *L. fusca, rugosa, inversa, implicita, gibbosa, tristis, ilicis,* and *hirticula*; and the injurious *Cyclocephala* is *C. immaculata.*

Life Histories of the Injurious Species.—The life histories of the white-grubs of the genus *Lachnosterna* are very imperfectly known, especially as to the length of time required for the growth and development of a complete generation. The literature of the subject records, in fact, but a single case in which a *Lachnosterna* has been reared from the egg to the adult. An egg of *L. arcuata* laid in Washington about June 8, 1893, hatched in approximately eleven days, and changed to the pupa August 8, 1895, and to the beetle twenty-three days later.[*] As this beetle would doubtless have hibernated in the earth to emerge the following spring and lay its eggs in June, the entire period from the egg to the egg again was three years. This is the length of the life cycle which has commonly been inferred, from circumstantial evidence, for our species of *Lachnosterna* generally. It is worthy of note, however, that *Melolontha vulgaris,* the European white-grub nearest in classification and habits to our American species, has been found, according to Xavier Raspail, to have, in France, a period of three or four years—the shorter period if the years are moist and the longer one if they are dry.[†] In Germany, on the other hand, this species has a four-year period at the north and a three-year period at the south, with various occasional exceptions and irregularities of appearance; and a related species, *M. hippocastani,* has a five-year period in north Germany. Our American species of *Lachnosterna* will probably be found to present similar variations of life history.

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[*] "Biologic Notes on the May-beetle *Lachnosterna arcuata* Sm." By F. H. Chittenden. Bull. 19, N. S., Div. Ent., U. S. Dept. Agr., p. 77.

[†] Bull. de la Soc. Zool. de France, 1891, p. 271; Mém. de la Soc. Zool. de France, 1893, T. VI., p. 202.

Whatever the length of life in the grub stage, all our most abundant species of *Lachnosterna* begin to pupate in June or July in central Illinois, and begin to change to the beetle in August or September, remaining, with rare or doubtful individual exceptions, under ground in this stage until the following March, April, or May. They then emerge from their winter quarters, feed on the leaves of various trees, and pair and lay their eggs in the earth in June and July. An exception should perhaps be made, provisionally, of *L. tristis,* concerning which my records are unusually imperfect, agreeing, so far as they go, with those of the other species of our list, but stopping short before the middle of June. That is, we have an abundance of the beetles collected from the latter part of March through April and May and into early June, most frequently, however, in May, but have no collections in any stage at any date later than June 5. Four of our lots of *tristis,* collected in March and April, were beetles taken from the earth, which must have transformed the preceding summer or fall.

Pupæ of the above species have been taken by us from their underground cells only in June, July, August, and September, and the adult beetles have been found under ground in the cells where they originated, in August, September, October, and November, and again in April and early May. Adults of various species have been seen pairing in May, and in one case in June, and eggs of seven of these species—*tristis* being omitted—have been secured in June and July, much the greater part of them in the former month. So far as my rather scanty records go, the eggs may be expected to hatch from ten days to four weeks from the time of deposit. My dates for the hatching of eggs of known species are, for *inversa,* June 23 and July 11; for *fusca,* June 27; for *implicita,* July 16, 21, and 24, and August 7; and for *hirticula,* July 7.

From this it will appear that white-grubs found in the earth beyond the middle of September will not change to the beetle that year, but, barring destruction by parasites and other fatal accidents, may be expected to pass the winter as grubs and to continue in that stage at least until the following June. This is a point of special economic interest, since the owner of infested fields needs to know whether the grubs in the ground during the latter part of the season will continue there in dangerous numbers during the following spring, or whether he may expect relief from their injuries by reason of their change to the beetle.

The data of my collections, when taken in the aggregate for several years, give little indication of any fixed order of succession in the first appearance of the different species of *Lachnosterna* in spring. *Inversa, fusca, rugosa, hirticula,* and *tristis* have all been taken by us in the later days of March, and *gibbosa* on April 6. *Implicita* and *ilicis* have made their first appearances about a month later than the average, but, although *implicita* is sometimes excessively abundant, these two species have been much less frequently taken by us than the others, and the record might have been different if the collections made had been equally numerous. The dates of last occurrence are also nearly the same for these species, and their periods of greatest abundance do not vary greatly.

Fusca, however, commonly appears in large numbers at electric lights about a week earlier than the other species, and *gibbosa* is about as much later than the others—a fortnight later than *fusca.* Our records of egg-laying are substantially the same for all the seven species covered by them. So far, consequently, as the mere period of adult activity is concerned, these insects are virtually one species, and we must look to other facts and conditions for any specific distinctions of habit or agricultural relation.

I find that the data of the relative abundance and dates of emergence of the various species derived from electric-light collections disagree widely with the data of collections made from the food plants of the beetles at the same time. Apparently some of the species are more strongly attracted to lights than others. In 1891, and again in 1906, collections were made at Urbana from trees and from lights during the greater part of the active period of the May-beetles, with the results shown in the following table.

LACHNOSTERNA AT LIGHTS AND ON TREES, IN COMPARISON. URBANA.

	1891		1906	
	Lights	Trees	Lights	Trees
No. Specimens	1874	836	142	3484
L. gibbosa	.02	.02	.00	.03
L. inversa	.76	.32	.54	.00
L. dubia	.00	.00	.02	.00
L. fusca	.05	.23	.00	.01
L. rugosa	.00	.00	.24	.06
L. implicita	.00	.00	.15	.72
L. hirticula	.10	.42	.03	.07
L. ilicis	.00	.00	.02	.10
L. tristis	.07	.00	.00	.01

In 1891, when 1,874 specimens were taken from lights and 836 from trees, the dominant species at lights was *inversa* (76 per cent.), *hirticula, tristis,* and *fusca* following with ratios of 10 per cent., 7 per cent., and 5 per cent. respectively. The dominant species from trees, on the other hand, were *hirticula* (42 per cent.), *inversa* (32 per cent.), and *fusca* (23 per cent.), the only other species being *gibbosa* (2 per cent.). The results for 1906, when 142 specimens were taken at lights and 3,484 at trees, were equally discordant. The leading species at lights this year was *inversa* (54 per cent.), *rugosa* and *implicita* following with 24 per cent. and 15 per cent. respectively; while the leading species in trees was *implicita* (72 per cent.), followed by *ilicis* and *rugosa,* 10 per cent. and 6 per cent. respectively.

Variation of Numbers in Different Localities and Years.—The numbers of the several species vary greatly from year to year in the same locality, and in different localities during the same season. It consequently happens that the dominant species in a locality may be different in successive years, and that the dominant species in one locality may be different from that in another, within the same year. Collections have not been made on a large enough scale or in sufficiently continuous series to enable us to exhibit these differences in any detail, but the following may serve as illustrations:—

Collections made at a street-lamp in Maywood, near Chicago, by O. S. Westcott,* on seventeen nights from May 9 to June 14, 1887, contained 798 specimens of *fusca* and 313 of *gibbosa*—*fusca* predominating in a ratio of more than 2½ to 1; and collections made the following year at the same place by the same person, on seventeen nights between June 2 and July 2, gave 73 specimens of *fusca* and 1,836 of *gibbosa*—*gibbosa* now predominating in a ratio of 25 to 1. The difference in the collection period of the two years was due to the difference in the weather of the spring, which was backward and stormy in 1888. If we compare the collections of the same periods for these two years—June 9 to 14 in 1887, and June 9 to 13 in 1888—we have 96 specimens of *fusca* to 82 of *gibbosa* in 1887, and 29 of *fusca* to 1,020 of *gibbosa* in 1888.

A similar comparison may be made between the contents of frequent collections from trees made at Urbana through the whole period of activity of the May-beetles in 1891 and again in 1906—836 specimens in the former year and 3,484 in the latter. (See table on p. 451.) In the collections of 1891 the dominant species were *hirticula* (42 per cent.), *inversa* (32 per cent.), and *fusca* (23 per cent.), the only other species represented being *gibbosa* (2 per cent.). In 1906, on the other hand, the dominant species was *implicita* (72 per cent.), the remaining species, mentioned in the order of their abundance, being *ilicis* (10 per cent.), *hirticula* (7 per cent.), *rugosa* (6 per cent.), *gibbosa* (3 per cent.), and *fusca* and *tristis* (each 1 per cent.). This latter comparison is vitiated, however, by the fact that the collections were made from different kinds of trees, those of 1891 mainly from butternuts and hickories, and those of 1906 from poplars, willows, elms, and oaks,—another example of the fragmentary and disjointed character of the data now available for a study of this subject.

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*"Entomologica Americana, Nov., 1888, Vol. IV., p. 155.

It so happens that extensive collections of May-beetles were made in 1888 both in Cook county, Ill., by Westcott, and in the District of Columbia by J. B. Smith,* and a comparison of the relative numbers of the dominant species in these two widely separate localities would be possible by their means if it were not for the fact that Westcott's specimens were all taken at lights and Smith's were obtained from trees and shrubs. As already shown, collections are not comparable when made in these different ways.

Much more nearly equivalent collections were made in 1906 by two assistants of my office, one working at Urbana, in Champaign county, between May 26 and June 23, and the other at Elliott, in Ford county, between May 23 and June 5, the first collecting at lights scattered through fields of grass a total of 142 specimens in ten nights, and the second obtaining at a single light in a large corn field 389 specimens in six nights. At Urbana the dominant species was *inversa* (54 per cent.); at Elliott it was *gibbosa* (71 per cent.). At Urbana *gibbosa* was not taken in these light-collections, and at Elliott *inversa* made but 20 per cent. of all obtained.

A further profitable comparison may be made of data contributed by Prof. M. V. Slingerland from the product of light-traps kept in continuous operation at Ithaca, N. Y., during the seasons of 1889 and 1892.† Four hundred and thirty-eight specimens of *Lachnosterna* were taken during the first of these years, and 273 during the second. *Fusca* was much the most abundant species in both years, making 76 per cent. of the product of the traps in 1889, and 90 per cent. in 1892. *Dubia* was next to *fusca* in 1889 (15 per cent.); and this species and *ilicis*, each 4 per cent., were likewise next to *fusca* in 1892. The similarity of the records for these two years is possibly due to a three-year period of the dominant species,

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*"Proc. U. S. National Museum, 1888, Vol. II., p. 488.

†Canadian Entomologist, March, 1893, Vol. XXV., p 81.

fusca, but, unfortunately, as no comparable collections were made in the intermediate years, the evidence is not complete. Westcott's Maywood collections, already referred to, on the other hand, hint at a two-year period for *L. gibbosa*. This species predominated over *fusca* in 1886, as shown by records made on five nights, from the 26th of May to the 1st of June, in a ratio of 3.6 to 1, and again in 1888, in a ratio, as already stated, of 25 to 1, but was much less abundant than *fusca* in the intermediate year.

FOOD AND FEEDING HABITS OF THE SPECIES.

The white-grubs and the May-beetles, larvæ and adults of the same insect species, differ totally in their food and feeding habits, the grubs eating the roots of various kinds of plants and the beetles eating the leaves of trees and shrubs. In the absence of any means of distinguishing the species one from another in the grub stage, no evidence has been obtained of any special choice, by any of the species in this stage, among the various elements of the food of grubs in general. So far as known, all of them may take, with equal relish, all kinds of food which any one of them will eat. If the different species of grubs do indeed make definite and varied choice of food, the fact may be ascertained by breeding to the adult, for determination, pupæ and full-grown grubs obtained in various situations near or among different kinds of food plants; but there is at present too little recorded information on this point to permit us to infer any difference whatever in the choices of our more abundant species.

The species of beetles themselves, on the other hand, differ considerably, although not sharply and completely, as a rule, in their choices of food where several kinds are equally accessible to them. Evidence of these preferences has been obtained by us in three different ways: (1) by experimental feedings with beetles kept in confinement; (2) by parallel collections of beetles made from different kinds of food plants; and (3) by the dissection of specimens of various species, made to determine, by an examination of the contents of their alimentary canals, what kind of vegetation they have been feeding on. The first method shows what the beetles may eat under stress of hunger, or perhaps with starvation as a penalty for refusing what is offered them; the second shows what the different species actually choose when a choice is open to them; and the third enables us to determine with certainty what the beetles have eaten where direct observation is impracticable. The results of our feeding experiments have been so different from those obtained by making collections from the food plants at night that they evidently have comparatively little real value. For example, leaves of Osage orange were offered, without other food, to *fusca, inversa, implicita, ilicis, rugosa,* and *tristis.* They were eaten moderately by *implicita* and *rugosa,* and slightly by *fusca, inversa,* and *ilicis,* but were constantly refused by *tristis.* On the other hand, extensive observations made in the field have given us no instance of actual feeding on this plant in the open air by any of our species, although it is everywhere in common use as a hedge plant.

The following table shows the different kinds of food offered to *Lachnosterna* beetles in breeding-cages in 1904 and 1905, and data as to the readiness with which each sort of leaf was eaten when but one kind of food was placed in the cage.

RESULTS OF FEEDING EXPERIMENTS WITH MAY-BEETLES (LACHNOSTERNA).

	Gibbosa	Inversa	Fusca	Rugosa	Implicita	Hirticula	Ilicis	Tristis	Average
Carolina Poplar, (*Populus monilifera*)..	1	3	3	3	3	3	3	2	2.62
Willow	–	3	3	2	3		3	1	2.50
Oak	–	2	3	2	2		3	3	2.50
Elm..............	3	2	3	2	2	3	3	3	2.62
Apple	1	2	3	3	3	3	3	1	2.37
Box-elder.........	1	2	3	1	3	2	2	0	1.75
Plum.............	1	0	3	0	3	3	2	0	1.50
Peach	1	0	1	0	1	1	1	0	.71
White Ash.........	1	2	1	1	3	2	1	0	1.57
Tulip tree, (*Liriodendron*)..	0	1	1	0	1	1	0	0	.57
Hedge............	–	1	1	2	2	–	1	0	1.40
Lilac.............	–	1	2	–	1	–	–	–	1.33
Cherry............	–	1	1	–	1	–	–	–	1.
Corn..............	–	2	2	2	2	–	1	0	1.50
Grass.............	–	2	2	2	1	–	1	0	1.60

1=slightly eaten, 2 =moderately eaten, 3 = freely eaten, 0 = refused to eat, – = not offered.

An attempt was also made to test the general food preferences of each species by offering several different kinds of food in the cage at once. Under these conditions, *L. fusca, inversa,* and *implicita* ate most freely of Carolina poplar and willow; *L. ilicis* and *hirticula* ate most freely of oak, but freely, also, of Carolina poplar and elm; and *L. tristis* ate only oak when that was present. *L. rugosa* selected poplar and elm, and *L. gibbosa,* oak and elm.

In 1906, at Urbana, extensive collections were made with equal care from each of the four different kinds of trees which May-beetles seemed to prefer as food. The beetles were gathered by shaking them from the trees at night and picking up those which fell to the ground.

The following table gives the results of these collections made at Urbana from Carolina poplar (cottonwood), willow, oak, and elm, on twenty-six different nights between May 14 and June 28, 1906.

COMPARATIVE COLLECTIONS OF LACHNOSTERNA FROM FOOD PLANTS. URBANA, 1906.

Species	Poplar		Willow		Oak		Elm	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
L. implicita	1456	.58	855	.34	35	.01	171	.07
L. rugosa	169	.85					31	.15
L. gibbosa	73	.72	7	.07	18	.17	4	.04
L. fusca	39	.85	6	.13	1	.02		
L. hirticula	10	.04	6	.03	209	.86	17	.07
L. inversa	5		4		2			
L. ilicis	2		1		317	.93	21	.07
L. tristis					25	1.00		
Total	1754		879		607		244	
Per cent. on each tree	.50		.25		.18		.07	

From the foregoing table it will be seen that poplar (cottonwood) was the favorite food, 50 per cent. of the specimens being taken from this tree, and that willow follows next with 25 per cent., oak with 18 per cent., and elm with 7 per cent., poplar and willow together yielding 75 per cent. of the insects. Apple leaves were often eaten freely, but no trees were suitably situated for experimental field-collecting, and hence no comparative records were made which included apple. Apple orchards in the southern part of the state have been reported by assistants as sometimes almost stripped of their leaves. This was notably so in Jackson county in 1904. The pecan- and persimmon-trees of southern Illinois often suffer severely by having their foliage eaten by the beetles.

Certain species of the beetles exhibited marked preferences in the choice of food. *L. hirticula, ilicis,* and *tristis* had a special liking for oak, the last named being taken from no other tree. *L. implicita, gibbosa, fusca,* and *rugosa* were most abundant on poplar, *rugosa* seeming to avoid oak and willow. Not enough specimens of *L. inversa* were taken to warrant conclusions concerning its preferences.

All of the May-beetles taken at lights in the open fields at night in 1906 at Elliott, Ford county, and at Urbana, Champaign county, were carefully dissected and the contents of the alimentary canals were examined microscopically. Nearly 40 per cent. of all the May-beetles taken had eaten nothing. This percentage was much the highest for specimens taken early in the season, 62 per cent., for example, for those caught before June 6. Probably most of these empty beetles had just come from the earth and had not yet begun to feed. Nearly all of those captured in the fields at lights which had taken food had eaten the leaves of trees, as was shown by the presence in their intestines of small pieces of leaves exhibiting the netted vein-structure and other characteristics of the foliage of the common trees of the vicinity. Only six specimens of about six hundred dissected, had eaten the leaves of young corn. Five of these specimens belonged to *L. rugosa* and the sixth to *L. inversa.* Four additional specimens of *L. rugosa* were taken at Urbana directly from corn while feeding on it. As these ten beetles represent only about 1¾ per cent. of the whole number examined, the facts indicated by them are of little economic significance except as going to show that May-beetles, of these two species at least, emerging in corn fields at a distance from trees too great to enable them to find their more ordinary food, may nevertheless subsist on leaves of corn. The same facts have been shown with reference to blue-grass, and it seems probable that, in the absence of other food, beetles may be able to live on the blue-grass of our pastures. With their actual powers of flight and their strong disposition to assemble in trees at night, not merely to feed but likewise to copulate, their ability to feed on grass and corn seems to signify but little. Corn, oats, wheat, clover, and grass fields were repeatedly examined in both Ford and Champaign counties with a view to the detection of any injury which might have been caused by these beetles. Occasionally at Urbana, and more frequently at Elliott, corn plants were found which, though uninjured in the evening, were partially eaten by the next morning, and, as already mentioned, four May-beetles (*L. rugosa*) were taken directly from the plants while feeding on them. Dissection of these specimens showed beyond a doubt that they had eaten the leaves of corn. Two hundred and sixty-two specimens of this species were taken in 1906, 169 of them from poplar, 31 from elm, and 62 from other situations, and only 9 of these had eaten corn, as shown by dissection.

MOVEMENTS OF MIGRATION AND DISPERSAL.

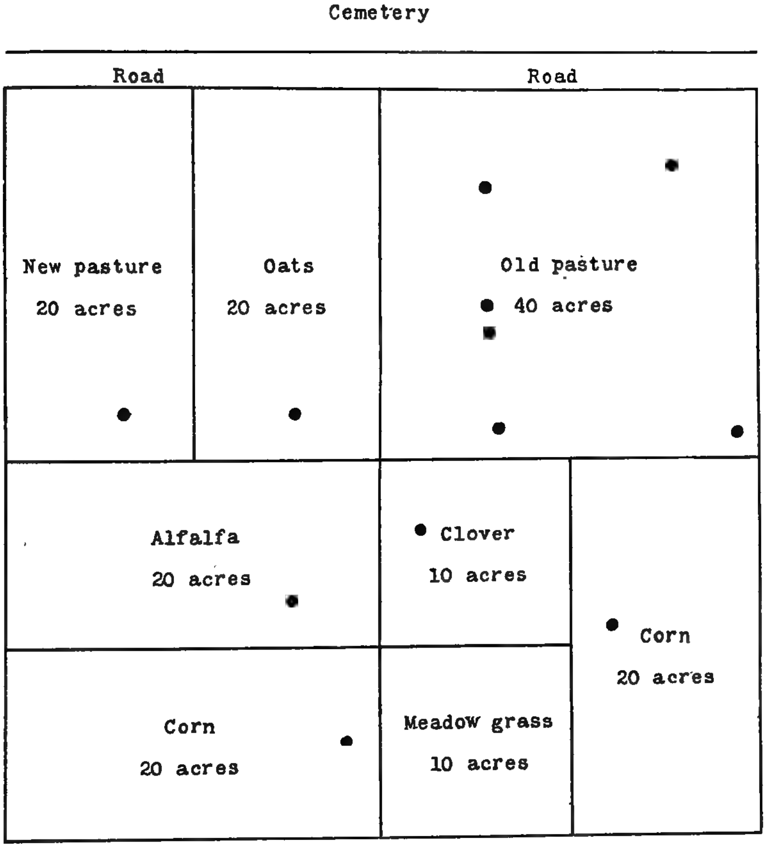
As the larvæ known as white-grubs never appear above ground except by accident, and as they are sluggish insects, incapable of rapid locomotion under ground, each is practically confined, so far as we now know, to the immediate neighborhood of its origin. The grubs change location slowly as their food is exhausted, and injured spots in an infested lawn or grain field will gradually enlarge in all directions, the white-grubs moving outwards into fresh pasturage as the infested vegetation dies from the destruction of its roots. The grubs also sometimes gather in from all directions towards a particularly attractive patch of their food plants; but there is nothing to show that they move from place to place by definite underground migration, or that they cover any considerable distance, such as to take them from one field to another, during the whole period of their active larval life.

The May-beetles also seem local in their distribution. Although very good fliers, they use their wings only to carry them from their place of origin to the trees and shrubs on which they feed and in which they copulate at night, and from these to their daytime hiding places, never moving in swarms, so far as known, or migrating over considerable distances. There is, in short, no evidence of any migration movement of this insect in any stage or under any circumstances, but each locality or considerable neighborhood probably breeds and maintains its own white-grub population year after year. Their most marked movements are the evening flight of the beetles to their food plants, and the morning dispersal from trees to the fields in which the females lay their eggs.

The discovery that certain species, at least, of the May-beetles may feed, and sometimes do feed to a small extent, on corn and grass, and the consequent conclusion that they may not need convenient access to trees for food, raises the important question whether some of these insects, and possibly certain species of them, may not live continuously in the fields, feeding on the crop plants there and laying their eggs in the very places where they themselves originated. If this is the case, collections made in the fields at maximum distances from trees should give us proof of the fact; and I consequently arranged, in the spring of 1906, for the systematic use of lantern traps distributed over an open area of one hundred and sixty acres on the main farm of the University of Illinois, with trees of various sorts in a cemetery along one side of this tract, and no others within less than half a mile from it in any direction. These traps were ordinary kerosene lanterns, with glass globes, placed over large tin trays, each containing kerosene to a depth of about half an inch. These trays were not large enough to secure all the beetles which flew against the lantern globes, but they nevertheless gave satisfactory samples of the beetles flying in the field.

The accompanying plat shows the crops of this tract and the distribution of the lantern traps in each. Forty acres were in corn, seventy acres in grass, thirty acres in clover and alfalfa, and twenty acres in oats. Two of the lanterns were in corn fields, two in clover and alfalfa, one in oats, and seven in meadows and pastures of grass. None were nearer than a quarter of a mile to trees on whose leaves the May-beetles were feeding at the time, nor farther from them than three quarters. To avoid attracting beetles from these trees, each lantern was provided with a tin shade by which its light was hidden on the side towards the trees nearest to it. These lights were

Plat showing Distribution of Light-traps.



kept burning all night for fourteen nights between May 20 and June 23 inclusive, and were visited at frequent intervals during each of these nights. The weather was so cold during four nights that the May-beetles were not flying, and no account is taken of these nights in this discussion.

The total product of the twelve traps, thus maintained for ten entire nights, was 142 specimens of May-beetles of the genus *Lachnosterna* and 25 specimens of *Cyclocephala*. No account is taken of the latter because their food habits are very different from those of *Lachnosterna*. The average product of a lantern in one night was only 1.2 of the true May-beetles (*Lachnosterna*), and the largest catch of any one night was 40 specimens on June 18, or 3⅓ per light. The largest collections were made on three nights between June 9 and 18 inclusive, these averaging 33 per night, or about 3 to each trap. The two collections of May, made on the 26th and 31st of the month, averaged only 6 beetles per night, or 1 to each two traps.

A single light-trap of the same kind, exposed at night without a screen, for ten minutes May 21 and for thirty minutes May 23, close to willow-trees at the border of this field and near the cemetery above mentioned, yielded 11 May-beetles on the first night and 127 on the second—seventy times as many taken in ten minutes by one trap near these trees as were taken at approximately the same date by a trap exposed all night in the open field. There could be no question, consequently, that very nearly all the May-beetles of this neighborhood were concentrated in the trees at this time.

New data have been obtained by our collections and observations of recent years with regard to the nightly movements of the beetles, and these are thus summarized by Mr. J. A. West, who had charge of this work for 1906.

"There is a regular migration of beetles from the fields to the trees in the evening. It takes place in June just about dusk—from a few minutes before to a few minutes after eight p. m. The movement of the beetles is almost simultaneous from the different fields. An observer in one field can scarcely move to another and hope to see the migration. It is usually but a few seconds from the time its beginning is noticed in one place until a companion observer will report its commencement perhaps a quarter of a mile away. Beetles were found rising from the ground in fields of oats, in pasture, old meadow, clover, alfalfa, and in corn. They were most abundant from old pasture and least numerous from alfalfa and corn. They were observed coming from the ground in considerable numbers in oats and clover fields. The following species are mentioned in the order of their abundance: *L. implicita, hirticula, ilicis,* and *rugosa.* The evening migration occupies not over fifteen or twenty minutes, and in every instance it seemed completed by 8:20 p. m.

"While the evening migration seemed to result in a complete abandonment of the fields by the beetles, yet the observer may now and then hear a beetle whirr past in the darkness at any hour of the night, and light-traps so placed in the open field as not to attract those from the trees will take specimens in small numbers throughout the night. The beetles distribute themselves regularly over large areas when they leave the feeding grounds in the morning. The following is a record of specimens taken in the fields a quarter of a mile or more from trees, and apparently coming directly from them: *L. implicita,* 11, *L. hirticula,* 5, *L. rugosa,* 31,—total, 47.

All these specimens were taken by hand, the light-traps not seeming to attract them.

"The morning movement is very early. It varies considerably, according to the clearness of the sky. It is so related to the awakening of the birds that it seems as if the first note of the dick-cissel, or other early bird, is the signal for the beetles to fly to their hiding places in the ground. On only two mornings were beetles taken in June after four o'clock. June 18, a dark cloudy morning, a pair of *L. rugosa* were taken at 4:25 a. m. while in copulation on a stem of grass. Ordinarily the movement did not last over fifteen minutes and it very rarely continued for twenty minutes. On the morning of June 7, however, a strong wind was blowing thirteen to fourteen miles an hour from the south. This greatly retarded the flight of the beetles which had been feeding on trees to the north of the fields, and on this morning it began at 3:35 o'clock and continued until 4:10, when the last beetle seen was taken in flight.

"The following notes show the variation in the time of the morning movement of the beetles according to the brightness of the morning and its relation to the awakening of the birds:—

"Morning of June 10, moonlight and very bright. Dick-cissel heard at 3:08; meadow-lark at 3:15; kingbird at 3:20; the following, in order given, from 3:25–3:35,—prairie-chicken, brown thrasher, quail, robin, and horned lark. On this morning the beetle-movement began at 3:18 and lasted until 3:30.

"Morning of June 18, very cloudy and dark. No bird was heard until 3:40, and the movement of the beetles began at 3:45 and was complete in ten minutes. About 3:30 a.m. was the average time for the first bird note, and 3:35–3:45 the regulation time for the morning movement of the beetles."

These data are of special importance as showing the time of night when the beetles are accessible in the trees on which they feed—a subject important to a discussion of measures of prevention and remedy.

HABITS OF REPRODUCTION.

With respect to the reproduction of May-beetles, we need to know at what time of day, in what situations, and especially how soon after emerging, the sexes pair, and when, where, how soon, and in what numbers the females deposit their eggs. Our definite information as to the pairing of the beetles is not abundant, but is sufficient to show that they pair at night on their food plants. The males are much more active than the females,—a fact illustrated by their greater abundance at lights in fields at a distance from trees. In the product of the light-traps used in 1906, as described in this paper under "Movements of Migration and Dispersal," pp. 458–460), the males outnumbered the females about 4 to 1, while in collections made at the same time from trees the number of males was only 39 per cent. of the total number taken. Similar data were given in my Seventh Report.* It will be seen that it does not follow from the greater number of females taken on the food plants that females are actually more numerous than males, but only that the latter are more widely scattered at night, and more generally on the wing.

It has been noticed by some of the office assistants, and particularly by Mr. J. A. West, that May-beetles are sometimes very unequally numerous in neighboring trees of the same kind, one tree containing a buzzing multitude while there are comparatively few on another tree of the same species close by. I have myself once seen a large tree so full of May-beetles in the evening that the noise of their movements was like that of a huge swarm of bees, although the condition of the leaves the following day showed that they had not resorted to this tree for food. Their assemblage in tree-tops is evidently in part for breeding purposes, and not wholly for food.

About fifty pairs of these beetles have been taken by us *in copula*, all but three of them from trees at night. In one case a pair of *L. rugosa* was captured at night by Mr. West from a grass-blade in a pasture, and two pairs of *L. inversa* have been seen copulating in a breeding-cage, also at night. These two pairs had been taken from earthen cells in the ground October 5, 1905, and transferred to the insectary, where they at once went into the earth, first appearing above ground on the 1st of the following May. They began to feed on elm leaves May 17, and paired at midnight May 25. Our observed dates of copulation all fall within the month of May.

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*Eighteenth Rep. State Ent. Ill., p. 117.

The several species of May-beetles may continue active, in a normal season, from one to two months, reckoning this period from the first appearance of the earliest specimens to emerge to the final disappearance of the beetles for the year. In our work of 1906 the dates of first and last appearance of the more abundant species in collections made regularly near Urbana, at night, from willow, oak, elm, and cottonwood (Carolina poplar), were as follows: *L. implicita,* May 13* and June 28 (46 days); *L. ilicis,* May 21 and June 23 (33 days); and *L. hirticula,* May 23 and June 18 (26 days). In New York, on the other hand, Professor Slingerland some years ago obtained *L. fusca* in his light-traps from May 6 to July 5, 1889, and from May 26 to June 28, 1892; *L. dubia* from May 8 to July 5, and from May 30 to June 22; and *L. ilicis* from June 1 to July 30.

CAPTURES OF LACHNOSTERNA AT LIGHT-TRAPS, OPEN FIELDS, URBANA, 1906.

	Inversa	Implicita	Dubia	Hirticula	Rugosa	Ilicis	Males	Females
May 26	4						4	0
May 31	6	1	1				5	3
June 2	8	3					5	6
June 4		6	1	3	4		8	6
June 6	2				3		4	1
June 9	18	1	1	2	7	2	25	6
June 15	22				5		24	3
June 18	16	9			15		40	0
June 20						1	0	1
June 23		1					0	1
Total	76	21	3	5	34	3	115	27

Collections made only from the food plants commonly show a more rapid diminution and earlier disappearance of males than of females. We may take as an example 2517 specimens of *L. implicita* collected from trees on twenty-six different nights between May 14 and June 28, 1906. Thirty-nine per cent. of the specimens taken during the first thirteen days were males and only 15 per cent. of those taken during the last thirteen days. On the other hand, in collections made during the same period by means of lantern traps scattered through the open fields, at a distance from the food plants of the beetles, the ratio of males to females was precisely twice as great during the last half of the period as during the first. Slingerland's data, already referred to, do not support the supposition of a relatively early death of the males. It seems likely, consequently, that females may require repeated fertilization, especially as the eggs are laid gradually, a few at a time.

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*The spring was unusually late this year, and May-beetles did not appear on the wing until May 13.

COLLECTIONS OF LACHNOSTERNA FROM TREES, URBANA, 1906.

	Implicita		Fusca		Gibbosa		Rugosa		Ilicis		Hirticula		Inversa		Tristis	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
May 14.....	59	90	3	1												
May 15.....	74	95	8	2												
May 16.....	27	52	5	3												
May 17.....	109	200	1													
May 21.....	24	23							1							
May 22	19	25			10				2	1						
May 23.....	193	239	7	7	8	2			3		14	5	2	1		
May 24.....	25	26			2				5	1	2	2				
May 25.....	31	35														
May 26.....	104	135	5	4	4	1			13	9	3	1			1	1
May 30.....	4	25							6	5	1			2		
May 31.....	50	108			17	2			28	24	45	21			6	5
June 1.....	24	125							4	3	12	6			3	1
June 2.....	45	129							8	8	12	4				
June 4.....	14	96			3				19	14	5	16			3	1
June 5.....	6	54					1		24	24	12	20			1	3
June 6.....	4	36			15	2	3	8	12	3	6	3				
June 7.....	1	9			20	16	4	17	12	5	7	7				
June 9.....	5	41					14	16	15	8	6	4				
June 15.....	4	27					7	13	21	39	8	12				
June 16.....		17					13	17	4	1	1	2				
June 18	12	76					13	37	16		2	3	1			
June 21.....		16					7	22	1							
June 22.....		3					3	4	1							
June 25.....							1									
June 28.....		1							1							
Totals																
Males	834		29		79		66		196		136		3		14	
Females..		1683		17		23		134		145		106		3		11

Our data show about thirty cases of oviposition by seven of our species in our breeding-cages, ranging in date from the 1st of June to the middle of July.* As the beetles have begun to emerge more than two months earlier, it is likely that they spend some time in feeding before oviposition begins. In the Eighteenth Report of this office it is said (p. 118) that the statement commonly made to the effect that the eggs are laid in a ball of earth is clearly erroneous. This assertion must be corrected in the light of numerous experiments made in my insectary in 1906 with May-beetles of several species, all of which so deposited their eggs in the ground that each was found inclosed within an earthen ball, a half inch in diameter, probably formed by the extrusion with the egg of an adhesive fluid which, upon hardening, held together the particles of earth which it had penetrated. This method of inclosure was so general that eggs were most easily found by sifting the dirt in breeding-cages and breaking open the spherical pellets of earth thus separated. The eggs were laid at depths varying from not more than an inch to five or six inches below the surface, the number for each female varying from 44 for a specimen of *L. inversa* to 67 for *L. implicita.*

The following extract from the breeding-cage report of Mr. J. J. Davis will give additional particulars of interest.

L. inversa. June 12, 1906, 1 female beetle in breeding-cage. June 18, the earth examined and 44 eggs found, each in a ball of earth from 3 to 3½ inches below the surface. Eggs of a pure milky color and of an oval shape, measuring 1¼ × 2 mm. By the end of three days they had swollen to a nearly spherical form, now measuring 2 × 2¼ mm. Hatching first observed July 11.

L. hirticula. Beetles collected and placed in breeding-cage June 19, 1906. No eggs were found till July 2, but July 9, 6 were found, each in its ball of earth. The freshest eggs were white with a glossy luster. They measured at first from 1½ × 2 mm. to 2 × 2½ mm. Five days later these eggs had swollen to 2 mm. in diameter, and were 2½ to 2¾ mm. in length.

L. ephelida. A single egg obtained August 4, 1905, from beetles collected at Carbondale, Ill., July 26, and placed in breeding-cage in insectary July 29. This egg was comparatively small and definitely oval, measuring at first 1⅓ × 2 mm., and later 1¾ × 2 mm.

L. ilicis. From beetles collected June 19, 1906, eggs were found in oval balls of earth July 9, none having been present there on the 2d of that month. The eggs were a dull white, quite different from the glossy luster of those of *L. hirticula.* They measured at first

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*A specimen of *L. ephelida*, taken July 29, 1905, at Carbondale, in southern Illinois, laid eggs until August 4.

1½ × 2½ to 2¾ mm., the shorter diameter later enlarging to 2 mm.

L. crenulata. From a single female beetle placed in a breeding-cage July 15, 1905, three eggs were obtained three days later, deposited at a depth of about an inch. These eggs were oval, measuring 1½ to 2½ mm. They were white when first laid, but changed afterwards to cream color.

L. fusca. Eggs were obtained June 22, 1905, from beetles which had been placed in a breeding-cage April 24. One of these eggs hatched on the 27th of June.

L. implicita. Adults collected at Elliott, Ill., from cells in the earth, were placed in a breeding-cage in the insectary October 13, 1905. They were first seen out of their winter quarters April 28, 1906. June 12, 1906, 3 females were alive and 6 eggs were found by sifting the dirt. On the 20th of June only 1 beetle remained alive, and this was a female. No more eggs were found up to June 25, but on the 5th of July 42 eggs were sifted out of the dirt, each in its separate ball of earth. These were from 5½ to 6 inches below the surface. Those most recently laid, measured 1¼ × 2 to 2¼ mm., while those which were longest deposited measured 2 × 2½ mm.

RELATIONS TO WEATHER.

The beetles of *Lachnosterna* transform from the pupa in summer and fall, remaining, as a rule, in their underground cells, from 2 or 3 to 5 or 6 inches below the surface, unaffected, so far as we know, by any degree of cold to which they are likely to be subjected in our climate. Their nocturnal movements after they come out of the earth are, however, easily influenced by the weather. During thirty-one nights, commencing May 14 and ending June 28, 1906, these beetles were studied and collected at Urbana by Mr. West. On five of these nights no beetles were seen or caught, although the fields, the lights, and all the best feeding grounds were visited. The records of minimum temperature for these five barren nights, and the rate and direction of the wind, were as follows:

Date	Minimum Temperature	Rate and Direction of Wind (Anemometer Record)
May 19............	41° F.	N. E., 6 to 8 miles per hour
May 28............	42° F.	N. E., 4 to 14 miles per hour
May 29............	38° F.	S. E., 6 to 12 miles per hour
June 11............	49° F.	N. E., 12 miles, all night
June 12............	46° F.	N. E., 14 miles, all night

No beetles were taken on any night when the thermometer registered below 52°, except May 21, when the temperature was 62° at 9 p. m. but fell to 46° before morning. A cold rain or high wind kept them confined at night to their day-time hiding places, and they were never abundant on their food plants, or flying freely, unless the minimum temperature was at least 60°. They appeared in greatest numbers on warm quiet nights following bright sunny days. The beetles continue feeding during rain if a storm comes up during a night favorable to their movements; and even their flights are not wholly suppressed by moderate rain if the weather is warm.

MODES AND PLACES OF HIBERNATION.

Our common white-grubs hibernate, in the latitude of central Illinois, in the two stages of larva and beetle, and in these stages only. In fifty-seven collections, distributed over several years, obtained by following the plow in fall and in spring, not a single pupa of these species has occurred, although recently transformed beetles, still inclosed in their pupal cells, have been collected by the hundred. The pupa of *Lachnosterna* may possibly go through the winter now and then, transforming the following spring, but this is certainly an extraordinary occurrence in our latitude, quite insignificant as a factor in the life history of the species. It is also a very unusual thing for the beetles to come out of the ground in fall. Indeed, those taken from the earth and placed in breeding-cages in either fall or early spring, commonly bury themselves without delay. Now and then a single specimen may be found active in fall, but we have seen but one such case in the course of our several years' work. The beetles are evidently more resistant to cold than the grubs, and do not attempt, as a rule, to escape by going farther into the ground with the approach of winter.

During the summer most of the grubs are near the surface of the soil. A small percentage may be found to a depth of eight or even ten inches, but the average is about three inches. In late fall they begin to go down as a protection against the approaching winter's cold, and may reach a depth of two to two and a half feet. In October and November, 1905, the downward movement of the grubs infesting a field of corn, part of which had been completely destroyed by them, was followed by digging over, on each of five days, several areas each three and a half feet square, and counting the grubs exposed. The following table gives the dates at which this search was made, the average number of grubs found for each square of three and a half feet, the range in depth of the grubs dug out, and the average depth for each date.

Date	Average Grubs per Square	Range in Depth	Average Depth
Oct. 3, 1905....	29.2	Near surface to 8 in.	3.5
Oct. 10, 1905....	22.6	Near surface to 10 in.	3.1
Oct. 23, 1905....	25.3	Near surface to 10 in.	3.1
Oct. 31, 1905....	22.	Near surface to 16 in.	6.4
Nov. 22, 1905....	24.75	Three in. to 23 in.	10.

November 22, the last of the above dates, most of these grubs were from 7 to 14 inches below the surface; but one was found only 3 inches down, seven had stopped at a depth of about 6 inches, and three had gone to 20 to 23 inches below the surface. The ground did not freeze permanently until several days after this date.

The grubs approach the surface in spring when the frost leaves the ground and the soil becomes fit to plow, and one often sees in the bottom of the furrow the tubular burrows made by them in coming up from their winter quarters.

PRINCIPAL ENEMIES.

Swine.—Pigs are by far the most destructive enemies of white-grubs and of May-beetles. They are extremely fond of these insects, and of all others within their reach which are large enough to attract their attention, and the diligence with which they will tear in pieces the sod of an infested pasture, and the depth to which they will dig in pursuit of grubs in cultivated ground are matters of common observation. They will also search out and destroy the May-beetles in May and June if allowed to range over pastures and meadows where these insects hide by day and to which they resort to lay their eggs. Pigs are consequently our most useful agents for the destruction of these insects—a point which will be more fully discussed in this paper under "Measures of Prevention and Remedy."

Crows and Blackbirds.—Next to pigs the most efficient destroyers of white-grubs among our common larger animals are crows and crow-blackbirds, both of which eat them greedily where they can find them in sufficient numbers to make them an important article of food. Evidence on this point is less positive with respect to crows than concerning blackbirds. Mr. W. B. Burrows, of the U. S. Department of Agriculture, who has studied the food of the common American crow by examining the contents of more than a thousand stomachs, reports that he has found white-grubs in a comparatively small number of these stomachs, but that May-beetles had been eaten by very nearly all the crows taken at a time when these insects were abundant in the beetle stage, making, indeed, the greater part of the insect food of all the crows collected at that time.

To these well-known facts I have to add two significant items of observation reported to me by my field assistants. One of these, Mr. E. O. G. Kelly, who was engaged during much of the season of 1906 in a field study of injuries by white-grubs, unusually serious that year in central Illinois, tells me that he often saw considerable numbers of crows following after the plow in fall, evidently picking up white-grubs, and that he has also seen flocks of crows alight in a badly infested pasture and tear the sod in pieces in search of the grubs, fighting with each other for their possession when thus exposed. Another assistant, Mr. A. O. Gross, employed last fall in collecting data for a census of the bird life of Illinois, found, in a trip across the state made on foot in September and October, that, next to the horned lark, crows were the most abundant birds on plowed ground, averaging seventy-nine per square mile in all the recently plowed fields crossed on that trip. They could have had no other object there than the search for insect food.*

In a study of the food of blackbirds, made by Mr. F. E. L. Beal for the U. S. Department of Agriculture in 1894, it was found that these birds ate either beetles or grubs in every month from March to October inclusive. In May these insects made more than a sixth, and in June one ninth, of the entire food. Many stomachs were found to be literally crammed with grubs; and in many more, grubs had formed a large part of the previous meal.

The Common Grub Wasp (*Tiphia*).—Much the most important insect enemy of the white-grubs is a wasplike insect belonging to the hymenopterous genus *Tiphia*. It is a slender, jet-black species, usually about two thirds of an inch long, but sometimes smaller, and with wings either clear or more or less deeply tinged with dusky yellow. It enters the ground in search of the grubs, follows them up in their burrows, and lays on the back of each grub a single egg, which hatches in a little over a week into a footless, maggot-like larva. This larva adheres to the surface of the insect, punctures its skin and sucks its blood for a time, but finally eats it up. The *Tiphia* larva then spins, under ground, an oval brown coccoon within which it goes through its transformations, coming out as a winged insect the following summer. The rate of multiplication of the species is not known, but it is certainly sufficient to enable the *Tiphia* virtually to destroy, under favorable circumstances, the entire grub population of a badly infested field.

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*"An Ornithological Cross-section of Illinois in Autumn." By S. A. Forbes. Bull. Ill. State Lab. Nat. Hist., Vol. VII., Art. IX., p. 318.

The method of the operations of this insect and the main facts of its life history have been worked out in my insectary during the past two years by Mr. J. J. Davis and Mr. J. A. West from coccoons and infested grubs sent in by Mr. Kelly from fields at Elliott, Ill. Thirty-three *Tiphia* cocoons were used in these observations, twenty-one of which were obtained November 25, 1905, and twelve April 27, 1906. From those collected in fall the winged insect emerged at thirteen dates between June 19 and July 28, 1906, and those obtained in spring yielded the adult on eleven dates between June 26 and August 22. These collections consequently do not represent different broods. Only seven of the adults obtained were males, and twenty-five were females, the sex of one being undetermined.

A pair were seen *in copula* in one of the breeding-cages at 9:30 p. m. July 1, and eggs were laid on grubs in the insectary from June 29 to August 21. One lot of young white-grubs brought in September 20, 1906, were already badly infested by very small *Tiphia* larvæ about one eighth of an inch in length. As insectary observations show that the eggs hatch in from seven to ten days, and that the young larva reaches the length of an eighth of an inch in about a week, it appears that the eggs for these larvæ were laid a little later than September 1. The period of oviposition of this grub wasp is thus something more than two months.

In several cases a female *Tiphia* was induced to go through the whole operation of preparing her victim and depositing her egg upon it above ground in a breeding-cage, where she could be continuously watched, and the facts thus learned are unusually interesting. Like others of its family—the digger-wasps, or *Scoliidæ*—these insects sting their prey before attaching the egg to it, with the effect to paralyze it more or less completely. Mounting the body of the grub, which struggles violently against the attack, the *Tiphia* seizes with her mandibles the skin of the back just behind the head, curving her body downward around the side of the grub, with the tip of her abdomen beneath and just behind the head, and then, after feeling about with the abdomen for a time, finally stings her victim, with the effect suddenly to quiet its struggles and reduce it to helplessness. Then the *Tiphia* reverses her position and works the tip of her abdomen backward and forward for several minutes in one of the grooves or creases on the back of the larva, usually not far behind the head, apparently smearing the surface there with a viscid fluid, after which she deposits her egg on this sticky surface and goes away.*

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*The above account is based on insectary observations and experiments. Several white-grubs parasitized by *Tiphia* larvæ have been found in the field since this was written, and in every case the larva was on the under side of the body between the thoracic legs.

The larva, at first almost completely paralyzed by the puncture of the sting and the venom doubtless injected at the same time, slowly revives, recovering presently its full powers of locomotion, so that it is indistinguishable by its behavior from its fellows which have not been stung. The stinging, in this case, is thus a means of quieting the struggles of the grub in a way to permit the *Tiphia* to attach her egg to its back. Commonly, of course, these operations go on under ground. A *Tiphia* introduced into a breeding-cage containing grubs in the earth disappears under ground herself, and does not come out until she has found and infested a grub.

Repeatedly, where grubs were exposed to attack on the surface of the dirt in breeding-cages, the *Tiphia* merely stung them at first, and then proceeded to bury them before depositing her egg. For this purpose, she undermined the grub by digging the earth from beneath it, pulling its body about by means of her jaws until it was in proper position to enter the hole, gradually digging deeper, and finally burying it completely. In one case in which the operation was timed, the grub was buried in ten minutes after it was stung. Sometimes the *Tiphia* abandoned an attempt at burial, and left the grub without placing an egg on it after it was stung.

Apart from that general exhibition of a wonderful adaptation of its actions to the needs of its prospective progeny which this *Tiphia* shares with many other wasps, and especially with those of its own family, there are two points of peculiar interest in this account It is an unmistakable fact that the effect of the poisoning of the grubs by the *Tiphia* is merely to paralyze the victim temporarily; to overcome its resistance and reduce it to helplessness while the *Tiphia* egg is being placed in position. The sting is used as a mere aid in the struggle of the *Tiphia* with a stronger insect. This fact may point to the explanation of the origin of the remarkable instinct of the solitary wasps to sting and paralyze their prey.

More remarkable still, however, in the light of our present knowledge of the habits of *Tiphia,* is its frequent burial of white-grubs exposed to it on the surface of the ground. Since digger-wasps in general are parasites of underground larvæ only, since the *Tiphia* is not known to infest any insects except white-grubs of the genus *Lachnosterna,* and since in nature it can never find these grubs above ground, its deliberate burial of exposed grubs has all the appearance of a line of action extemporized to meet a previously unknown condition. Either the *Tiphia,* disturbed at finding its prey exposed, buries this as a result of impulse aided by intelligent contrivance, or we shall find, when its habits are known in full, that it does sometimes normally infest and attack insects exposed above ground by their habits, burying them as a matter of instinct after it has placed its egg. *Tiphia* has not, in fact, been studied as an independent species, but all the data concerning its habits and life history have been gathered in the course of studies of the white-grubs.

The egg of *Tiphia* remains firmly glued to the back of the chosen grub, and hatches in seven to ten days. The young larva breaks its way out from the egg at one end, and, although it begins at once to feed, it does not at first free itself from the shell, but as it grows this finally splits and breaks away. When it first emerges the larva measures slightly more than a millimeter in length. From our scanty data it appears that it takes about two weeks to get its full growth, and that it doubles its size in the last two days of its larval life, during which it is engaged in devouring the body of its host. Previous to this time it has been adherent to the skin of the grub whose fluids it has lived upon. When full grown it is from two thirds to four fifths of an inch in length.

The cocoons are cylindrical ovate, from 17–22 mm. long, clay-colored at first, and wood-brown or cinnamon-brown when older. From our observations thus far made it appears that the larva hibernates within the cocoon, not pupating until the following spring. The adult emerges from a little one side of the larger end, in which it leaves a ragged and irregular opening. In several cases the abundance of these conspicuous brown cocoons in the earth was such as to indicate an enormous destruction of white-grubs, and there is no doubt that this parasite is an important agent in checking destructive uprisings of these insects.

That this wasp, parasitic on white-grubs, is itself parasitized, is shown by the results of observations made on *Tiphia* cocoons collected April 27, 1906, and kept in breeding-cages during the summer. From these emerged, July 7, 16, and 31, adult bee-flies (*Bombyliidæ*) of the species *Exoprosopa fascipennis*, each freeing itself from the *Tiphia* cocoon by cutting out a circular piece at the larger end. The eggs from which these flies resulted were probably laid on the *Tiphia* grub in 1905, before the cocoon was spun.

MISCELLANEOUS INSECT ENEMIES.

Macrophthalma disjuncta.—This little tachinid fly was mentioned in my Seventh Report as bred repeatedly from dead white-grubs, but I was nevertheless uncertain that it was a parasite. Lately its parasitic nature has been proven by repeatedly breeding it from living grubs kept in breeding-cages in my insectary. Adults have emerged in these experiments March 26, June 8, July 12, and August 8, and others have been taken at electric lights July 9, and in a corn field September 27. Those appearing March 26 lived in confinement until May 14. We have thus seen these insects alive in every month from March to September inclusive. In the breeding-cages, remains of a white-grub were commonly found associated with the cocoon of the parasite.

The adult of this species is a large blackish-gray fly with a general resemblance to the common large blow-fly, but with a grayish white sheen on the basal half of each segment of the abdomen, giving the effect of equal alternating cross-bands of black and gray.

Ophion bifoveolatum Brullé.—This well-known parasite of the white-grub has been reared by us several times from these insects. In one case the head and skin of a grub were woven into the wall of the cocoon of the parasite. The species has been bred by us repeatedly from cocoons collected from the latter part of July to the first of September, and kept in breeding-cages through the winter, adults appearing from March 31 to April 27.

The adult is a large, slender-bodied, dark red ichneumon-fly; and the cocoon is quite regularly elliptical, a half inch long by a fourth of an inch thick at the middle, smooth, dull brownish, or more or less blackish—especially towards the end.

Sparnopolius fulvus Wied.—This bee-fly, which we have sometimes noticed in corn fields and have collected from miscellaneous sweepings of vegetation in midsummer, also proves to be a parasite of the white-grub, as shown by breeding-cage work done in 1904—1906. It was first detected in this relation by Mr. E. P. Taylor, of my office, who found a white-grub at Elliott, Ill., August 25, 1904, with a dipterous larva attached to its back. This was placed in an insectary cage, which was not examined until April 21, at which time the white-grub had been completely destroyed, and the larva had completed its transformations. It probably had emerged in the fall of 1904. A larva of this same species was next collected July 24, 1906, from among corn roots at Effingham, Ill., and was placed in a breeding-cage to obtain the adult. It pupated August 22, and emerged as a winged insect September 10. All our open-air collections of this fly have been obtained in August.

The adult is about as large as a common house-fly, but is covered with erect yellow fur. The pupa is not inclosed in the last larval skin. Its head bears three large points on each side anteriorly, and a smaller pair beneath at the base of the mouth-parts. The last segment of the pupa is rather narrowly truncate, with a small slender spine on each side of the truncation, and a shorter one beneath each of these.

Considerable numbers of another species of parasitic larva were taken by Mr. Kelly at Elliott, Ill., August 29 and September 20, 1906. These were evidently white-grub parasites, as the remains of the grubs were still clinging to several of them. This species is still in the larval stage at this writing.

Three yellow coarcate meloid larvæ were also found by the same assistant in an infested oats field with the remnants of white-grubs attached to them, and another was taken in a similar condition October 10. These specimens have not yet matured.

Pyrgota undata Wied.—One of the most interesting parasitic enemies of the white-grubs is a large, rather unusual-looking fly of the family *Ortalidæ,* noticed by Mr. J. A. West, an assistant of my office, as abundant among the beetles at night. Now and then May-beetles were seen to drop to the earth, trying to rid themselves of the adult flies which were clinging to their backs, each with the last segment of the abdomen thrust in between the wings and wing-covers of the beetle and firmly held in place over the middle of the abdomen. The flies were apparently thus thrusting their eggs into the backs of the beetles through the thin dorsal skin beneath the wing-covers. The tip of the abdomen of the female fly is admirably adapted to this object, being hard and subconical, and directed downwards at a right angle to the axis of the body.

The relations of these insects were experimentally determined by confining, June 9, 1906, adult May-beetles in a breeding-cage with several of the flies. These would light on the backs of the feeding beetles, which would at once drop to the ground with the flies clinging to them. Whenever a beetle spread its wings for flight the insect on its back inserted the tip of its abdomen between the May-beetle's wings, evidently depositing an egg in its back. Beetles so treated lived for some days, and then began to die. On the 27th of June, five of the beetles were dead, and in the bodies of two of these, dipterous maggots were found. July 10, three of the beetles contained each a dipterous puparium, which remained unchanged until May of this year, when all produced adults of *P. undata.* August 29 and September 20, 1906, several puparia were found in the bodies of dead May-beetles, and these, kept in breeding-cages through the winter, produced adults of *P. undata* May 14 and 17, 1907. Like experiments begun during the present year have progressed similarly to the time of writing. Adult flies of this species were again frequently seen June 12 to 18, 1907, among May-beetles on trees at night, no less than twenty-six specimens being captured. These flies have also been occasionally taken at electric lights, and in various situations by day during different years, from May 20 to June 17.

The puparia of these parasites are dull black, broad ovate, widest at the posterior third. At the tip is a small shallow excavation encircled by a rugose ridge, which is elevated latero-dorsally into a pair of short irregular tubercles, the tips of which are about a millimeter apart. Length 7–8 mm.; greatest diameter, 4.5–4.8 mm.; diameter of anterior end, about 3 mm. The adult flies are yellow-brown, three eighths to half an inch long. The head is subtriangular, the thorax globose, the abdomen slender at base, enlarging apically. The wings are three eighths to half an inch long, conspicuously and characteristically marked. The entire anterior margin of the wings has a broad brown border reaching half way across the wing, and having two broad saw-tooth-like extensions attaining the posterior margin, one at the middle of the apical half and the other at that of the basal half. The first two abdominal segments are about as long as broad, and connate; the next four, in the female, are very short, followed by the genital segment, which is very large, shining, directed downwards and curved slightly forwards.

The male abdomen is similarly shaped: the two basal segments are followed by two more about twice as long as the corresponding ones in the female; the next segment is a little longer than broad, vertically directed, bearing the genital segment, which is directed somewhat anteriorly. The eyes are larger in the female than in the male.

Other Dipterous Parasites.—In 1905 a May-beetle of the species *Lachnosterna crenulata* found near Urbana July 15, laid three eggs, and died about the 29th of July. On August 5 an adult tachinid emerged from the body which Mr. Tyler Townsend, of the U. S. National Museum, regards as a new species—*Viviana.* Two dipterous larvæ were found June 27, 1906, in a May-beetle taken alive May 31. July 10 these larvæ had formed puparia, and adult tachinid flies emerged May 17 and 18 of the following year. These are slightly larger than a house-fly, with black subquadrate thorax, the anterior angles each with a triangular red spot. The puparium is very dark red, almost black, subcylindrical, with rounded ends. Length, 7 mm.; width, 3 mm. It is smoothly rounded behind, with a pair of low tubercles placed close together. The species has not been determined.

RELATION TO SOIL AND SUBSOIL.

It is a matter of common opinion that injuries by white-grubs are more serious on the higher, lighter, and drier parts of our cultivated areas than on the lower and moister parts, but no exact obsevations have been made to show whether this apparent difference is real under all conditions, and whether, if so, it is due to a greater abundance of the grubs on high lands than on low, or to a lesser average power of recuperation and resistance on the part of plants growing in comparatively light and less fertile soils.

I began in 1904 and 1905 to accumulate data on this and allied points, by having collections of white-grubs made by persons following the plow, who recorded for each field and situation the number of grubs found in each quarter of a mile of furrow. A record was also made, for each field examined, of the succession of crops it had borne for the five years preceding, of the character of the soil, the lay of the land, the conditions as to drainage and to fertilization, and the relation of the field to trees and shrubs on which the parent beetles of the grubs might have found food. Collections were made on this plan from seventy-nine fields in the following twelve counties of central and southern Illinois: Stark, Peoria, Woodford, McLean, Champaign, Macon, Macoupin, St. Clair, Washington, Marion, Jackson, and Union. This work was interrupted by lack of funds and by diversion of assistants to more pressing problems before any sufficient mass of data had been obtained to enable me to draw satisfactory general conclusions on any one of the points of principal interest. So far as they go, they show that the grubs were more abundant on the higher and drier parts of the country than on the lower and moister parts, and that the fewest eggs were laid by the parent beetles in corn fields and the most in grass-lands. Thirty-eight low-land fields gave an average of 21 grubs exposed in a mile of plowed furrow, and 41 of the high-land fields an average of 31 to the mile. The three largest numbers found in any fields were 208, 164, and 140 grubs to the mile, all on high ground. The largest numbers in any of the low-land fields were 112 and 104 in two of them. Again, the average of fields which had been in corn continuously for at least three years preceding was 17 grubs exposed in each mile of furrow, and that of fields which, although in corn at the time, had been in grass for several years preceding, was 37 grubs to the mile. It is evident that useful information may be obtained from data of this description if they are accumulated in sufficient number and are properly classified.

RELATIONS TO AGRICULTURAL MANAGEMENT.

Injuries by white-grubs are influenced to a considerable extent by the system of farming, and especially by the succession of crops; by the management of pasture-lands, in which, if left wholly to themselves, they are likely to accumulate in increasing numbers year by year; and possibly, also, by the time of the year when infested lands are plowed. While the old idea that white-grubs are essentially insects of pastures and meadows has been exploded by observations of recent years, it still remains true that, other things being equal, they are most abundant in grass-lands, and consequently most injurious to other crops if these follow within one or two years upon an infested pasture or meadow. They seem particularly liable to accumulate in an old turf which has lain unbroken for several years, and are less likely to be destructive where there is a quick rotation of crops, including a short period in grass, to be followed by one or two years in clover. The modern stockman's practice of herding cattle and pigs together is an excellent one from our standpoint, since the pigs, in following the cattle, are likely also to search out the grubs in the turf and to keep the sod practically free from them.

It is a matter of common, though not universal, opinion among farmers who have watched the work of the white-grubs that fall plowing of infested lands is preferable to spring plowing. In the absence of any apparent reason why this should be so, and in the absence also of any experiments upon the subject and of any considerable number of exact observations, this supposition must be regarded as doubtful. Our own field reports give thus far but a single instance, reported by Mr. Kelly in 1905, of a notable difference in white-grub injury corresponding to a difference in the time of plowing of different parts of the same field; and this instance is by no means clear, since there was injury by grubs in both parts of this field—much greater and more extensive, however, on the spring plowing. The white-grubs were also reported as less abundant in the part of the field plowed in fall, averaging there one grub to the hill of corn as compared with seven to the hill found in the part plowed in spring. The data of this observation are incomplete, however, and this difference in number of grubs may have been due to something else than difference in the time of plowing.

INJURIES TO CROPS.

Injuries to crops by white-grubs and May-beetles are often of the most serious and extensive character. The beetles by their destruction of leaves of trees and shrubs in spring not infrequently cause the death of those preferred by them for food, and the grubs are particularly destructive in towns to the turf of lawns, in nurseries to young evergreens, in the fruit plantations to strawberry vines, and on the general farm to grass and corn.

The injury by grubs is due, in all cases, to the destruction of the roots of the plants infested and the consequent weakening or actual killing of the plant. The nature and extent of the injury to corn is well illustrated by observations made by one of my assistants, Mr. Kelly, in a field near Ludlow, in Champaign county, about ten acres of which were almost completely destroyed. By digging up to a depth of twenty inches, and searching all the soil belonging to each of sixty hills of corn—an area, that is, three and a half feet square for each hill—it was found that this badly injured area contained an average of 3,460 grubs to the hundred hills, or more than 34 to the hill,—a total of about three hundred pounds of grubs to the acre of corn. The plants varied in height from two inches to six feet, and the total number of ears borne by two thousand hills was 786, all small ears or nubbins.

PREVENTION AND REMEDY.

The subject of preventive and remedial measures was somewhat fully treated in my Seventh Report (pp. 127–137), and there is nothing important to add to that discussion at the present time beyond a statement of the results of an experiment with pigs as a means of clearing the grubs out of an infested field. This experiment was made in the field above referred to, near Ludlow, Ill., ten acres of the worst injured part being surrounded with a temporary fence, and one hundred pigs averaging seventy-five pounds each, together with eight large sows, being turned into the inclosure September 23.

By October 13 the pigs had rooted over the whole surface of the ten-acre lot, going, in some places, to a depth of ten or twelve inches. An area equivalent to twenty corn hills was now examined to a depth of twenty inches, with the result that an average of 4.8 grubs per hill were found, as compared with 34.6 per hill at the beginning of the experiment—a benefit of 86 per cent. in twenty days. The grubs found in the field at this time were usually eight inches or more below the surface.

The pigs were in this inclosure until October 20, when they were removed to another badly injured part of the field, and a final examination of the plot was made. In an area equal to ten hills of corn only two grubs were found—a benefit of over 99 per cent. destroyed by the pigs in twenty-seven days. As the grubs were at this season going down to escape frost, the hogs were burrowing in pursuit of them, sometimes to a depth of two feet.

Although these pigs remained perfectly thrifty, it is proper to say that there is one possibly serious objection to this very common use of swine as a means of keeping in check the white-grubs in grass-lands and of clearing them out of fields of corn. It has been shown by Dr. C. W. Stiles, of the U. S. Bureau of Animal Industry,* that one of the most injurious intestinal parasites of swine, known as the giant thorn-headed worm (*Echinorhynchus gigas*), passes one stage of its life in certain of the white-grubs, and that pigs become infested by it by devouring infested grubs, which themselves obtain it by way of the excrement of the pigs. Where either grubs or pigs become infested by these parasites the situation is more or less dangerous if pigs are allowed to eat the grubs; but pigs which have never been pastured are certain to be free from these parasites, and grubs growing in fields which have not been pastured by pigs are likewise certain to be free from them. The use of such pigs upon such fields would consequently be without danger from this source, and a little attention to these facts will avoid any injurious consequences. That is, if pigs not previously allowed to run out are turned into fields on which pigs have not been pastured within three years, there will be no danger that they will become infested by these thorn-headed worms.

The general measures discussed in my Seventh Report are essentially a destruction of the May-beetles before they have laid their eggs, and the distribution among the grubs of the germs of their contagious diseases. Nothing has thus far been done to test the possibility of the collection and distribution of parasites other than those of contagious diseases, and the latter subject can not by any means be said to have been worked out to final conclusions.

The May-beetles may be destroyed either by spraying repeatedly with arsenical poisons the trees on whose foliage they feed; by shaking or jarring them down in the cooler parts of the night from the trees and shrubs on which they are feeding, and collecting them for destruction; and by trapping and killing them at night by means of lanterns fastened over tubs or traps containing water covered with a film of kerosene. The grubs may possibly be kept in check by the distribution among them of the germs of their contagious diseases obtained by artificial cultivation,—a method which has been

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*"On an American Intermediate Host of *Echinorhynchus gigas*." By C. W. Stiles. Zool. Anz., Feb., 1892, p. 52.

used with some success against the white-grubs of France. The main dependence in the Old World, however, has been a thoroughly organized movement for the collection of the beetles from the trees at night, the usual method of securing general action being to pay a sufficient price for the beetles in quantity to make their collection a profitable enterprise during the time of their presence on the trees. This method can be used to advantage only by owners of very large estates or by communities or combinations of farmers acting together for their common benefit. The same may be said of the destruction of the beetles by poisoning their food. If the ordinary land owner were to proceed by himself, it is probable that his fields would become infested by invasion from without even though he might destroy every May-beetle on his own premises. The least promising of these methods is the simplest and the cheapest of them all—that of collecting the beetles by lantern traps. These take effect much the most strongly upon the males, and collect, under the most favorable circumstances, only a comparatively small percentage of the beetles in their neighborhood. Furthermore, it is available only on dark and relatively quiet nights.

What may be done by way of general concerted action is well illustrated by a campaign of destruction carried on against the white-grubs of the Swedish province of Halland during the ten years from 1885 to 1895, within which time 29,736 bushels of May-beetles and their larvæ were collected at an expense of $15,554, or about 52 cents a bushel, the state usually paying half of this sum, the Economic Society of the province a fourth, and the communes or counties the remaining fourth. The effect was especially shown in the gradual reduction in the number of the beetles collected—from 14,801 bushels in 1887 to 5,611 in 1895, although the number of communes participating in the work had increased in the meantime, and the area covered by the collections was correspondingly greater.*

So far as is now to be foreseen, organized work of some such description will finally be necessary to the control of the white-grub pest in Illinois, and throughout America generally.

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*August Lyttkins, in Entomologisk Tidskrift for 1897. Stockholm, 1898.

BULLETIN

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NEW YORK STATE MUSEUM

OF

NATURAL HISTORY.

No. 5.

November, 1888.

THE WHITE GRUB OF THE MAY BEETLE,

By J. A. LINTNER, Ph. D.,
State Entomologist.

PRINTED FOR THE MUSEUM.

ALBANY:
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The White Grub of the May Beetle,

Lachnosterna fusca.

It may safely be asserted that the last twenty-five years have been signalized by greater progress than had been made in the preceding century, in economic entomology — that science that, through the study of insect lives and insect habits, tends to promote the comfort, welfare, happiness, and prosperity of society at large. In every direction it has shown a marked advance — in a knowledge of the insects with which it has to deal, the various insecticides employed for the destruction of injurious species, the mechanical devices used in the application of insecticides, and a wide distribution of the results of the studies, in these several directions, of our ablest entomologists. So marked has been this progress, that I need not at this time dwell upon it, for it must be evident to all who have given the slightest attention to the study. Insect depredations, to an extent elsewhere unknown, imperatively demanded that means should be found for their control. In recognition of the need, and in response to the call, provision, through State aid of the means essential to the study, was made, and those were found who were ready to devote themselves enthusiastically to the work. As the result, we are able to say, that there is to-day, within the reach of our agricultural community, a literature which offers them means for protection from their insect foes, superior to that of any other country of the globe. But, while boasting of this progress, I should fail of giving honor to whom honor is due, if I neglected to recall the fact, that at the very basis of this progress lie the labors of Dr. Asa Fitch, called to his work thirty years ago by the New York State Agricultural Society, and sustained therein for nearly a score of years, by appropriations obtained from the State, through the instrumentality of the Society. True, the labors and writings of Dr. Harris, of Massachussetts, in his studies of insect habits, and of preventive and remedial measures against a few species, initiated economic investigations, and prepared the way for more extended research; yet comparatively little could be accomplished in so vast a field, until specialists could be summoned to the work, prepared to devote to it their entire time, and their best abilities.

But the progress of which we boast is only great by comparison with the ignorance that formerly prevailed, when directions were given in our agricultural journals "how to destroy *the* cut-worm,"* and "how to prevent caterpillar attack." When measured, however, with what remains to be accomplished, the work seems but barely to have been entered upon — so immense is the number of species to be studied, so varied are their habits, and so secretly are many of their depredations conducted. While the last decade has contributed to our literature the life-history of a large number of destructive species, and has enabled us to find their most vulnerable point of attack and the most effectual means of destruction, there still remain several of our more injurious pests, which, as yet, we know not how to control, or how to prevent at times their wresting from us the products of our toil or the objects of our pride.

We need not be ashamed to make this confession. It in no degree invalidates the importance of entomological investigations. It is simply a consequence of the partial investigations thus far made — commenced only by those who have but recently passed off the stage, and continued by a paltry number of successors; for, as I have elsewhere stated, there are not within the 3,000,000 of square miles comprising these United States, more than ten persons who are permitted to devote their entire time to the furtherance of economic entomology. If, by a wise provision, this number could be quintupled, through each one of the several States contributing its quota, what rapid progress might be made through such an increased and diffused coöperation. My experience of thirty years in the study of insects enables me to make the assertion, that *there is not a single insect pest, the depredations of which we can not materially control, whenever its entire life-history becomes known to us.*

The exposed habits of the larvæ of most of our Lepidoptera (butterflies and moths), they being external feeders by day upon various plants, shrubs and trees, have made them comparatively easy subjects for study. It is different when we have to deal with

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* In the genera of *Agrotis*, *Mamestra*, *Hadena*, and a few others closely allied, over four hundred United States species of moths have been described, the larvæ of most of which, if not all, may be classed as *cut-worms*.

Coleoptera (beetles), where the larval or grub stage is generally concealed. This is why the early stages of so few of our Coleoptera have as yet been discovered and described.

When, in addition to a hidden, subterranean, larval life, we have also in the life-history the perplexing element of a greatly prolonged and unknown larval stage, the problem of how best to deal with our insect foes becomes a difficult one. In the Coleoptera, among the *Elateridæ* and the *Scarabeidæ*, we have two groups which unfortunately are in this category. The life-histories of the *wire-worms* and of the *white grubs* are unknown to us, and even the duration of their larval period has not been definitely ascertained. They are among the more serious pests of the agriculturist, and we do not know how effectually to prevent their depredations. Many experiments have been tried for their control, some of which have been partially successful. Not awaiting more positive and perfectly satisfactory results, it seems proper that there should be furnished the public from time to time such an epitome of what has been ascertained as may permit of its beneficial use.

It is therefore proposed, at the present, to present a summary of our knowledge of the May beetle, *Lachnosterna fusca* (Frohl.).

The larva of this species has, by common usage, received the name of "the white grub." It is not a well-chosen name, since there are several allied forms to which it might be quite as well applied, but it serves, from its general adoption, the purpose of separating it from other insects when we would speak of it. The perfect insect has in like manner been named the May-bug or May-beetle, and the June-bug or June-beetle. As it is a frequent visitor in our houses, where it is attracted to light, nearly every person, doubtless, has made its acquaintance in childhood. It is a thick-bodied insect of an oval form, and of a dark brown color, and measures

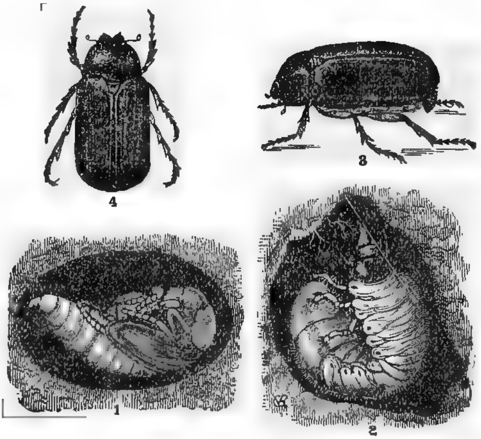

FIG. 1.—The May-bug, LACHNOSTERNA FUSCA; 1, the pupa; 2, the white grub in its ground cell; 3 and 4, the beetle.

about eight-tenths of an inch in length. Its wing-covers are shining and smooth, with the exception of two or three slightly elevated lines on each, and numerous minute impressed dots. The short antennæ terminate in three yellow leaflets or plates. The breast is covered with fine, glossy, yellowish hairs, from which it (together with the other species of the genus) owes the generic name of Lachnosterna, signifying *woolly-breasted.* The legs are tawny yellow, with black upon the joints. In the accompanying figure it is shown in a side and back view in 3 and 4.

THE WHITE GRUB.

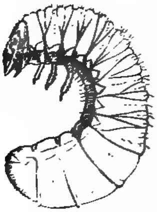

FIG. 2.—The white grub.

The larva may be characterized as a large white, soft grub, with some scattered fine hairs, a flattened, brownish or light mahogany colored head, with six distinct, rather long legs on the front part of the body (the first three rings), and the hinder portion of the body considerably the thickest, as shown in the accompanying figure. When taken from the ground, it usually assumes a curved form, its head and terminal end nearly meeting. When full-grown it is almost the size of a man's little finger. In the preceding figure, at 2, it is represented as lying within a cavity made by it in the ground, while feeding upon the roots of its food-plants.

There are several other "white grubs," similar to this in general appearance, but as they have habits in common, to a great extent, it is not necessary, except where observations are desired for scientific uses, that they should be readily separable. From a very similar species, however, which occurs in manure, it is important that it may be distinguished, lest proper manuring should be withheld, through fear that the May-bug would be conveyed with it. The May-bug grub does not occur in manure, as its food consists of living vegetable matter.* The grub which is frequently found abundantly in dung-hills, and may be met with under the droppings of cows in fields, is exclusively a dung feeder. It is known in some localities as the "muck-worm." Its scientific designation is *Ligyrus relictus* Say. The following features, by which the two may be separated, have been pointed out by Mr. Walsh. In the latter species, there may be seen on its back through its semi-transparent skin, along the entire length of the body, a lead-colored line, denoting its intestinal canal filled with the black dung upon which it has fed. In the true white grub, the *L. fusca* larva, it is only near the terminal end of the body that it shows a lead-colored appearance, because it is only at this portion of the canal that the roots upon which it feeds have become digested and converted into a dark-colored excrement (*Practical Entomologist*, i, 1866, p. 60).

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* The grub appears not to be exclusively a vegetable feeder, for it has been observed feeding on the eggs of the Rocky Mountain Locust, *Caloptenus spretus* (Riley, in Rept. Commis. Agricult. for 1883, p. 174).

THE EGG.

"The eggs are white, translucent, spherical, with an average diameter of 0.09 inch. They are deposited between the roots of grass, and are inclosed in a ball of earth before deposition, as the cavity is sufficiently large for the egg to roll about in." (Riley, Fifth Report, 1873, p. 55.)

It would appear that the above is given from the personal observations of Prof. Riley, or upon reliable information communicated to him. If this be so, then the following statement communicated to the *Country Gentleman*, of August 27, 1874 (p. 547, c. 4), can not be accepted: "Two years ago, I repeatedly saw in a garden the female depositing her eggs while flying—just at dusk—an inch or so above the ground: These eggs were polished white, as large as pigeon-shot, and dropped singly. This is in contradiction to the 'authorities,' for it is stated that the female digs again into the ground and deposits about thirty eggs in one hole" (T. J. Burrill, Champaign, Ill., professor of botany in the Illinois Industrial University).

Beyond the above, I have no knowledge of any publication of observations upon the egg-laying of this species, the construction of the ball of earth in which the eggs are said to be first inclosed, or the manner of its burial. How the ball-making and its burial to a considerable depth, in sod, can be accomplished by the aid of feet so seemingly unfitted for such operations is incomprehensible to me.

INJURIOUS CHARACTER OF THE INSECT.

The May-beetle may with propriety be named among our most injurious pests. It has attained the unenviable notoriety of being pronounced "one of the very worst and most insidious of the farmer's foes." If a list of our insect enemies were arranged in the order of relative importance, this species would, I think, find place among the first twenty. It is a native species, and very early notices appear of its serious injuries. It was first described nearly one hundred years ago — in 1792. Unfortunately, its depredations are evidently upon the increase, particularly within our own State, as appears from the following extract, and from the numerous inquiries received by me, of late, for approved and effectual means for the arrest of its ravages.

From Washington county, N. Y., in 1881, we have this statement: "The widespread havoc which this insect has caused this year, and the fact that its ravages are increasing with alarming rapidity, is my excuse for referring to the subject. The damages in this county amount to, probably, thousands of dollars annually, and are increasing."

The extent that these depredations have already attained is a sufficient warrant for this present notice of them. In their consideration, those committed in the early stage of the insect — that of the grub — will first be referred to.

INJURIES FROM THE GRUB.

Dr. Harris writes: "They subsist on the tender roots of various plants, committing ravages among these vegetable substances, on some occasions of the most deplorable kind, so as totally to disappoint the well-founded hopes of the husbandman."

To Grass.— Dr. Fitch thus notices it: "These grubs feed upon the roots of grass and other plants, which they cut off a short distance beneath the surface; and when they are numerous they advance under ground like an army, severing the turf as smoothly as though it were cut with a spade, so that it can be raised up in large sheets, and folded over or rolled together like a carpet. Often from a dozen to twenty grubs will be exposed in every square foot when the turf is thus raised. Large patches of this kind will occur in the middle of a meadow or pasture, every blade of the grass being brown and dead" (*3d, 4th and 5th Repts.*, 1859, p. 53).

In some pasture lands near London, Ontario, throughout entire fields "the roots of the grass had been so eaten that the turf could readily be lifted by the hand by the yard, and underneath were thousands of the grubs feeding on the remaining fragments of the roots. In one instance, a field had been so completely destroyed that the farmer had set fire to the withered grass, with the hope of scorching the enemy to death" (*Canadian Entomologist*, xiii, 1881, p. 200).

A report from North Pawlet, Vt. (*New England Homestead,* Nov. 8, 1884), states: "There is, at a low estimate, between three hundred and four hundred acres of land in this town that looks as barren as our roads, so far as anything green is visible. In our back lots a good deal of the dry turf has been turned over by skunks, coons, foxes and crows, in search of the grub."

To Corn.— The accounts given of its destructiveness to corn are numerous. Not only does it cut off the young corn when a few inches high, but it will also destroy full-grown corn over entire fields. On Prairie Ronde, in Michigan, it appeared in such numbers as nearly to destroy many fields of corn. Upon examination of a few corn stalks left standing in a field, the roots were found eaten off to within a few inches of the stalk, and often from three to five large grubs in a hill. Most of the corn was killed early in the season, and the few stalks left were dying a lingering death, without producing any grain (*Practical Entomologist,* i, p. 60).

A gentleman from Nine Mile Prairie, Missouri, writes: "They are destroying whole fields of corn. I have seen fields where they have destroyed the corn in patches for rods around, leaving the ground as bare as the traveled road. They seem to destroy the tap-root first, and afterward prey on the laterals" (*Practical Entomologist,* i, p. 61).

From Washington county, N. Y., we have this statement and estimate of injuries to corn from the grub, in the year 1881: "A large area of corn, in the aggregate, has been badly injured or entirely destroyed. On my own farm they caused the loss of one hundred bushels of corn alone; much of it would pull up by the roots when struck by the knife, frequently exposing to view from five to fifteen grubs" (*Country Gentleman for Dec.* 29, 1881, p. 851, c. 3).

Mr. Glover records their extraordinary abundance in Grayson county, Virginia, in 1874, where as many as one hundred and ten were counted in a single hill. They were also, during the same year, quite destructive to corn crops in Huntington county, Indiana, and in Montgomery county, Missouri (*Report of the Commissioner of Agriculture, for* 1874, p. 129).

To Strawberries.— It has long been known as especially addicted to feeding upon the roots of the strawberry. Prof. Forbes, in his excellent *Address on Insects Affecting the Strawberry,* read before the Mississippi Valley Horticultural Society, at New Orleans, on February 22, 1883, represents it (page 27 of Author's edition) as "perhaps the most unsatisfactory insect with which the strawberry-grower has to deal, offering the fewest opportunities for effective attack. The roots of the plant are often destroyed by it to a degree to impair seriously the value of the plantation." Mr. B. D. Walsh has written of it that it "is particularly destructive to strawberry beds and is probably one of the chief reasons why this plant will not last more than a few years on the same spot of ground in this country" (*Pract. Ent.*, iii, p. 60). Dr. Packard records its ravages at Salem, Mass., where many plants were killed by its eating the main roots and thus passing from one plant to another (*Third Report Inj. Ins. Mass.*, 1873, p. 6).

To Potatoes.— In Washington county, N. Y., during the year 1881, the grub is charged with having devoured whole fields of potatoes.

Hundreds of bushels were reported as having been made unfit for market, in North Pawlet, Vt., in 1884, by the grubs having eaten holes into them (*New England Homestead, for Nov.* 8, 1884).

To Wheat.— Of its injuries to wheat and other grains, Professor Webster has written: "During autumn there is hardly a field of wheat here in Indiana that does not, to a greater or less extent, show the effects of their voracious appetites. Their method of work in the grain fields seems to be much more erratic than in grass lands, as the many clusters of from two to twenty, or perhaps more, dead plants that have been eaten off below the surface, illustrate. Their work in spring wheat, and oats during spring, is usually less noticeable, and we have never observed the grubs feeding on the roots of spring-sown grain later than the fifteenth of May."

To Barley. — Professor Webster also reports that the larvæ were observed in the University Experiment farm at La Fayette, Ind., cutting off the roots of the full-grown and fully-headed grain. As late as the twenty-eighth of June they were causing whole stocks of the straw to wither and die before the kernels had filled (*Ann. Rept. Comm. Agriculture, for* 1886, p. 575).

INJURIES BY THE BEETLE.

Many of our insect pests are injurious only in their larval stage, except through the evil that they originate in the deposit of their eggs. Of this class are all of the extensive order of Lepidoptera, embracing the butterflies and moths, which, in their winged stage, are unprovided with jaws for biting. Their slender and flexible tubular proboscis, fitted only for imbibing liquids, can not be used for any serious harm—in this particular, unlike the rigid, stouter proboscis of the Hemiptera or bugs, which is capable of inflicting serious and varied injuries. The powerful jaws with which many of the Coleoptera, or beetles, are armed, are often fitted for, and employed as, formidable instruments of offense. The May-beetle while, from the character of its food and a life-period of short duration, it is less injurious than its insatiate and long-lived grub, is still chargeable, as a leaf-eater, with extensive depredations at times upon many of our fruit, forest, and shade trees. Dr. Fitch has written of them as "gathering by night upon the trees and eating the leaves, sometimes in such numbers as to wholly strip the foliage from the choice varieties." Prof. Riley states: "I have known the Lombardy poplar to die, in consequence of the utter denudation they caused; while groves of both pin and post oaks [*Quercus palustris and Q. obtusiloba*] * * * were thoroughly and suddenly denuded by them" (*First Report Ins. Mo.*, p. 157).

Of the fruit trees, the cherry and plum appear to be preferred. It was thought by Mr. Walsh that their swarming upon these trees, as they occasionally do, was not usual, except in the eastern States, as he had not known it to occur in the valley of the Mississippi (*Practical Entomologist*, i, 1866, p. 62). But that they are, at times, quite as abundant in that region appears from the record, that in Cameron, Missouri, "they swarmed during the last of May, 1866, making a noise on the trees like the coming up of a storm of wind and rain" (*American Entomologist*, i, 1868, p. 37). Among other trees, the beetle is recorded as feeding upon the oak, the maple, and the beech.

Mr. W. L. Devereaux, of Wayne Co., N. Y., writing in 1886, states: "The May-beetle is very abundant in this county this year, and it has completely stripped the foliage from most of the late infoliating trees like the species of walnut, ash, and oak (*The Husbandman for June* 23).

ABUNDANCE OF THE BEETLE.

The immense numbers in which the insects sometimes congregate in seasons of their unusual abundance is so well known that two notices only will be given of such gatherings. A correspondent from Central Maryland has sent me the following paragraph:

> The land seems to be full of them. They lie quiet during the day, but in the night, in the neighborhood and around and among the branches of two weeping willow trees near my house they make a continuous humming noise with their wings, and after the sultry evenings the noise made by them is a continuous roar all through the night.

In the *Rural New Yorker*, of July 10, 1886, is the following notice of an extraordinary flight of the beetles:

> An immense swarm of June-bugs settled down on Pekin, Illinois, Monday evening. Millions of them flew against an electric light on a street corner, and were burned to death. Five wagon loads were gathered up afterwards from the ground beneath the lights, and thrown into the Illinois river.

LIFE-HISTORY.

When I say that the life-history of this insect is not known, I offer the best reason for our inability to give effectual means for preventing the heavy annual losses that it inflicts upon us. The brief outlines of a history that are to be found in our entomological reports appear to have no better foundation than a presumed agreement with that of the European cockchafer, *Melolontha vulgaris* — a very poor basis, it may be remarked, for, long as that notorious pest has been known and studied, the knowledge of its transformations is far from complete. Dr. Harris gives no details, but contents himself with the very broad statement that "the habits and transformations of the common cockchafer of Europe * * * will serve to exemplify those of the other insects of this family." Even so accurate an observer as Dr. Fitch, thoughtlessly and unwisely, we think, committed himself to the following statement: "Every thing known respecting the history of our May-beetle and its transformations concurs to show that it is exactly analogous to the cockchafer or May-bug of Europe." In truth, the European cockchafer, of whose excessive abundance and ravages at times we have had such graphic accounts, is not closely allied to our May-bug. It belongs to another genus — *Melolontha* — which is entirely unrepresented in this country.

Professor Riley presents the following history, unaccompanied with the authority or observations supporting it: "Soon after pairing, the female beetle creeps into the earth, especially wherever the soil is loose and rough, and after depositing her eggs, to the number of forty or fifty, dies. These hatch in the course of a month, and, the grubs, growing slowly, do not attain full size until the early spring of the third year, when they construct an ovoid chamber, lined with a gelatinous fluid, change into the pupæ [shown in the accompanying figure], and soon after into beetles. These last are at first white, and all the parts soft, as in the pupa, and they frequently remain in the earth for weeks at a time, until thoroughly hardened, and then, on some favorable night in May, they rise in swarms and fill the air. It is very probable that under favorable conditions some of the grubs become pupæ, and even beetles, the fall subsequent to their second spring; but growing torpid on approach of winter, remain in this state in the earth, and do not quit it any sooner than those transformed in the spring. On this hypothesis, their being occasionally turned up in the fresh beetle state at fall ploughing, becomes intelligible" (*First Report Ins. Mo.*, p. 157).

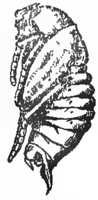

FIG. 3.—The pupa of the May-beetle.

In all thus far written of the transformations of this insect, the element of uncertainty largely prevails. It does not appear that the larval life-duration has in a single instance been ascertained, and many such determinations would be required in order to establish a rule of uniformity or the range of variation. Observations sufficiently reliable for use in building up a life-history are almost wholly wanting. The following are of some value:

In Clinton county, Missouri, the beetles swarmed late in May of 1866, from which eggs were doubtless deposited in June (the female *is said* to live for about a week). The grubs [from these eggs] were small, and not very injurious in 1867. They were "full-grown, fine, fat fellows," in the autumn of 1868 (*American Entomologist*, i, 1868, p. 37). From the above we educe: If the larvæ were then as reported, full-grown, the beetles from them would appear in May of 1869, three years from their preceding appearance. The grubs may have either transformed into pupæ in the autumn of 1868 or spring of 1869—in the third year of their life. Their larval period would then have been either two and one-third or two and three-fourths years.

Dr. Packard records his having found the pupæ "in little rude cells or chambers, about six inches under the mould * * * in Maine, late in May" (*3d Report Ins. Mass.*, 1873, p. 7).

I will here quote, from its obscure resting place, where it seems to have been overlooked, a somewhat circumstantial history of the transformations of this insect, which from the absence of technicalities and its general character, would seem to be the personal observations of the writer, and, therefore, of considerable value. It is from the *Patent Office Report* for the year 1852, Pt. ii, *Agriculture* (p. 219), and is a portion of a report upon the crops of Ulster county, N. Y., made by David L. Bernard, of Clintondale.

Corn is extensively cultivated in this county, and is considered most remunerative at present. It seldom fails with us to produce a fair yield, except in seasons when the *larvæ* of a beetle are present with us. When these *grubs* prevail to a considerable extent, neither good husbandry nor high manuring can secure us a crop; and perhaps no other county has for the past twenty years suffered more loss from this, than Ulster. This formidable enemy to agriculture seems gradually to be leaving us, in all probability to appear in some other place, and there to renew the same destructive process practiced on us. In order to give this *beetle* a slight introduction to whom it may concern, I will give a brief description of its general appearance and habits. The bug or beetle is about three-fourths of an inch in length, of a dark brown color, and may be seen in large numbers flying through the air, in the early part of the evening, about the last of April or first of May. They deposit their eggs generally in the month of June, on grass land, on soil that is light or loamy. The larva is hatched from the egg during the month of August, and feeds upon the roots of vegetables until the ground becomes frozen; it then descends below the frost, and there remains in a state of torpidity until the following spring. As the frost leaves the ground it ascends to the surface (exhibiting no increase of growth during the winter), and again resumes its former mode of living, carefully secluded from the rays of the sun; feeding on the roots of almost all kinds of grasses and vegetables. Its movements are slow and sluggish; its color nearly white, with the exception of the head, which is red; it has six legs, three on each side; it is at this age about one inch in length. It continues its destruction of all green vegetable matter with which it may come in contact, until the ground becomes frozen again. This is its most destructive season through its progress of change. As the ground becomes frozen, it again descends below the frost (in some instances six feet below the surface), as before remains torpid until the next spring, when it again appears at the surface, being now about one and one-quarter inch in length. It continues to feed as usual upon vegetable substances until about the middle of June, when it ceases to feed, descends deeper into the earth, and becomes torpid until about the middle of August, when a complete change occurs. It opens lengthwise from the head, back near one-half its length, and forthwith appears in the chrysalis state, in which it remains nearly inactive until about the last of September, when it changes into a perfect state or beetle, and still remains in a nearly torpid state until the following spring, when, about the last of April, it ascends to the surface and immediately commences to reproduce its species.

It has thus far baffled the ingenuity of man to prevent its ravages, while fields of timothy have, within a few weeks, been entirely destroyed by this grub, and thousands of acres of corn have been totally lost in this county by its ravages.

According to the above statement, the larval stage proper would be of the duration of *two years.*

DISTRIBUTION.

This insect is one of very extensive distribution, being found in all parts of the United States, and extending northward into British America, where it occurred in Kirby's collections in north latitude 54° — the latitude of Labrador and Hudson's bay.

ITS ENEMIES.

An excellent reason for the amount of injury which this insect imposes upon us is found in the few insect or other enemies that prey upon it, protected as it is by its subterranean life in its first three stages, and its unusually brief final stage. Only one insect parasite is known to attack it. It has, however, several vertebrate enemies which render good service in restraining its unlimited increase; these will first be noticed:

The Skunk.— There is abundant testimony of the service rendered by skunks in the destruction of the grubs, and to the expertness which they manifest in the discovery of their presence, and in making them their prey. It has been thought that one reason among others for the multiplication of the grub in localities in the Western States and elsewhere is to be found in the wholesale slaughter of the skunk since their skins have obtained commercial value as a fur. In the *Country Gentleman* of December 1, 1881 (p. 778, col. 2), we have the following observations: "A few years ago, before skunk skins became so valuable as furs, I had a pair of half-tamed skunks which I used to let out every evening to dig for grubs, and it was wonderfully interesting to see their infallible scent or instinct in discovering the location, and then their astonishing celerity in digging out and gobbling the grubs. But most astonishing of all was the quantity of grubs those two little beasts would devour every evening. I have often watched them, and, incredible as it may seem, I could not say that they ate less than half a bushel daily!" To the above statement, the suggestion is added, that a very valuable ally might be obtained in our war against the white grub by removing the odoriferous glands from the skunk, and domesticating him for employment as a grub killer.

Mr. Hoard, of Wisconsin, has made the following statement: I once had eight acres of hops, in which the white grub was very destructive. I went through the hops one morning, when there had been a couple of skunks in the hops in the night, and I found by actual count that they had investigated 400 hop hills, and I thenceforth became a very firm friend of the skunk (*Trans. Wisc. St. Agricul. Soc.*, xix, 1881, p. 298).

A correspondent of the *Practical Farmer* had watched the habits of skunks for twenty years, and found their natural food to be insects. He had a field of corn attacked by the white grub, in which he afterwards observed numerous small, round holes where these insects had been taken out by the skunks and devoured. He believed that the skunk should stand first in the list of insect destroyers, as it fed upon other noxious insects in addition to the white grub (*Country Gentleman for Jan.* 25, 1877, p. 527).

A correspondent from Washington county, N. Y., gives this testimony: "Before skunks began to be hunted, we had no trouble with the white grub, and I think they kept them down. I often found my corn-hills rooted into, evidently by skunks in search of grubs. Those dug into early in the season made a fair crop, while those untouched until later were destroyed. I have also seen the same signs in meadows and pastures" (*Country Gentleman*, Dec. 29, 1881, p. 851).

Not only are the grubs so eagerly sought for and devoured by this animal, but it is also, according to Dr. Fitch, a natural destroyer of the beetle, its food consisting almost entirely of this insect during the short period of its existence (*Third Fitch Rept. Ins. N. Y.*, p. 55). This is in accordance with the statement of Dr. Harris, to the effect that the beetles are devoured by the skunk, whose beneficial foraging is detected in our gardens by its abundant excrement filled with the wing-cases of these insects.

The Raccoon.—Dr. Thomas (*Sixth Rept. Ins. Ill.*, p. 98) names the raccoon as one of the carnivorous animals that prey upon this insect, but does not state to what extent it destroys it.

In the report from North Pawlet, Vt., page 9, it is mentioned as one of the animals that had been digging in the dry turf for the grubs that had caused the death of the grass.

The Fox.—In the same report, this animal is also included among those which had been rendering good service to the farmer, and the following suggestion is added: "There is now a bill before the Legislature authorizing the State to pay one dollar a head for all foxes killed in the State. Now, if these grubs continue with their sad havoc from year to year, I should think it a wise legislative act to pass a law prohibiting the killing of all wild beasts and birds which subsist in part on these grubs."

The Mole.—Professor Claypole, a careful observer of the habits of insects and other animals, permits us to claim the mole as an auxiliary in our warfare against the white grub. The following is what he saw, writing from Yellow Springs, Ohio: "In digging potatoes this year, I observed the runs of a mole in all directions through the ground. It was a piece of old sod, and very much infested with white worms, the larva of the cockchafer, *Lachnosterna fusca.* Many of the potatoes had been partly eaten by these worms, but I observed that wherever a mole-run traversed a hill of potatoes no white worm could be found, even though the half-eaten potatoes were proof of his former presence. The inference is fair that the mole had found him first and eaten him, and very likely the mole's object in so thickly tunneling this piece of ground was to find these grubs" (*Canadian Entomologist*, xiv, p. 17).

A writer in the *Indiana Farmer* says: "Last year I put twelve moles in my strawberry patch of five acres to catch the grubs, and they did the work. I never had a dozen plants injured during the summer, either by the grubs or moles. I know some people do not care for moles on their farms, but I want them in my strawberry patch."

The Gopher.—In Michigan, upon some new land badly infested with white grubs, and where the gopher was also abundant, the attempt was made to exterminate these animals, until they were observed, in the autumn, busily engaged in digging up and eating the grubs.

The Frog.—This animal undoubtedly destroys large numbers of the beetle, at the time when their destruction would be of the greatest benefit, during the night of their emerging from the ground and before they have deposited their eggs. Dr. Hoy, of Racine, Wis., relates that on the twelfth of June, having occasion to go across a little piece of prairie, he saw a large spotted frog, *Rana* ——, very large and hardly able to jump. He captured and opened him, and to his surprise found within him eight May-beetles. Others were caught and examined, and each was found to contain from one to four of the beetles (*Trans. Wisc. St. Agricul. Soc.*, xix, 1881, p. 297).

Other Mammals.—Among the mammals appointed to check the ravages of the cockchafer and allied leaf-beetles in Europe, according to Latreille, are the badger, weasel, marten, bats, and rats. The same animals, no doubt, render more or less service in restricting the increase of the May-bug in this country.

Domestic Fowls.—If these be watched as they follow the plow in our gardens and fields in search of such insects as may be brought to the surface, it will be seen that they show a special fondness for the white grub. Their presence during the operation of plowing should, therefore, always be encouraged.

The Crow.—The common crow feeds upon both the beetle and the grub. It is believed by many that its frequent occurrence in corn-fields is the result of its fondness for the grub, which is preying upon the young corn, rather than for the corn itself. The studies that have been so ably conducted during the last few years upon the food of birds should have settled ere this the question beyond all doubt, whether the crow is to be driven from, or invited to, our corn-fields.

Mr. Glover states that this bird has been observed to return on the appearance of the dor bug or May-beetle, and to feed greedily upon it both in its winged and larval stages.

Other Birds.—The beetles have been found in the stomach of the king-bird, *Tyrannus Carolinensis*, shot in the month of May. The robin, black-birds and jays are also said to feed upon them.

The grub has been taken from the stomach of the sparrow hawk, *Falco sparverius*.

Insects.—The grub has also enemies among its own class, which prey upon it. Several of the predaceous beetles are said to devour it — species of the rapacious *Carabidæ*, probably *Calosoma calidum* and others, but their names have not been recorded.

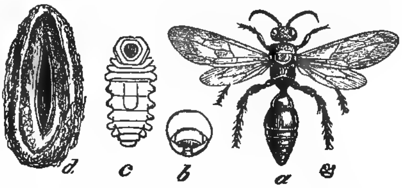

FIG. 4.—The white grub parasite, TIPHIA INORNATA.

A Parasite.— While many insect attacks are restrained through the beneficent aid of other insects, which, in our gratitude, we are apt to regard as specially commissioned to perform this duty for our protection, thus far we know of but a single parasite which is waging warfare upon the white grub. This insect was described and figured by Professor Riley, in his *Sixth Report on the Insects of Missouri* (1874, pp. 123, 124), as the white grub parasite — *Tiphia inornata.* It is shown at *a* in the accompanying figure. It is one of the digger-wasps, and the ease with which these creatures are able to burrow in the ground enables this one to discover the grub in its concealed retreats, and by depositing an egg upon the body, to provide for its progeny its needed food, and to insure the death of the attacked grub. The parasitic larva, shown at *c*, having matured, it incloses itself for its changes in "an egg-shaped cocoon of a pale golden-brown or buff color, and with a soft exterior surface, in touch as well as color. * * * Upon cutting this cocoon open, it will be found to consist of about a dozen delicate layers, the outer ones soft and loosely spun, the inner ones more and more compact and paler in color." The cocoon is shown at *d* in the figure. Their presence in the ground (from the above description and figure they may be easily recognized) serve to show the parasitic attack. They have in some instances been met with in such numbers, in association with a formidable grub attack, as to arrest attention and to induce inquiry into their character.

For an interesting mention of a secondary parasitic attack — the larva of the *Tiphia,* in its turn and while within its cocoon, is destroyed by a beetle known as *Rhipiphorus (Emmenadia) pectinatus* Fabr., var. *ventralis* — see Riley, *loc. cit.*, p. 125.

From a paper recently read by Mr. Otto Lugger, before the Baltimore Naturalists' Field Club, it appears that the Rhiphophora parasite above mentioned, which destroys the Tiphia parasite, has a parasite which also destroys it. Mr. Lugger had found within the Tiphia cocoons small hymenopterous parasites — the species not stated—showing this interesting order of events: The larva of a large Coleopterous insect (*Lachnosterna fusca*) is destroyed by a hymenopterous larva (*Tiphia inornata*); this in turn by a Coleopterous larva (*Rhipiphorus pectinatus*); and this again by a Hymenopterous larva (——— ———).

In connection with the parasitic attack on the white grub, it is of interest to note that Dr. F. Brauer has lately discovered a very interesting parasite upon *Rhizotregus*, an European genus belonging to the same group with *Lachnosterna*. Within its nearly formed pupa, he has found the second larval stage of a dipterous insect, *Hirmoneura obscura*—one of the bee-flies, the genus of which is represented in the United States. It is still not known when and in what manner the parasite enters the Rhizotrogus grub, but it was thought to be while the latter is in the larval state (*Science*, iii, April 18, 1884, p. 488).

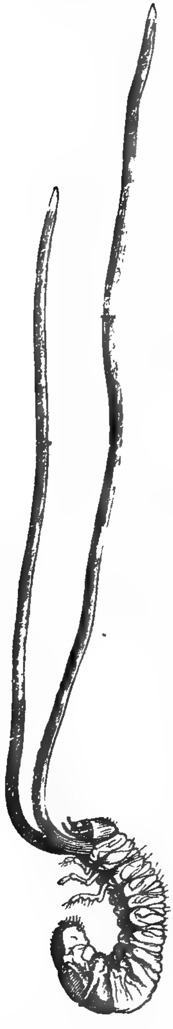

FIG. 5.—The white grub attacked by a fungus.

The White Grub Fungus.—For another destroyer of the white grub, and the most interesting of all that we have referred to, we have to turn to the vegetable kingdom—to that low class of plants known as *fungi*. From its being so often found upon this species, it has been popularly named *the white grub fungus*. Scientifically, it is known as *Cordyceps Ravenelii* Berkeley.* It was described in 1857, but its economic importance in its association with the white grub was not known until brought to notice by Walsh in 1867 (*Practical Entomologist*, ii, 1867, p. 116) upon the reception of specimens from a large number of the grub killed by this growth, which had been plowed up in a field in Iowa. Its character was not understood at the time, Mr. Walsh suggesting that, but for the numbers found, the grub might have swallowed a seed which subsequently sprouted and grew. Later, its fungoid character was disclosed. Its general appearance is that of a pair of elongated horns, green at first, but subsequently changing to brown, issuing from the lower side of the larva, between the head and the first joint. In length they vary from less than that of the larva, to three or four times as long. Its appearance, when it has attained the latter length, is shown in Figure 5.

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* Originally described as a *Cordyceps*, and subsequently referred to other genera, it has recently been restored to the *Cordyceps* of Fries, in *Sylloge Fungorum* of P. A. Saccardo (vol. ii, 1883, p. 573).

This interesting parasite occurs at times, in considerable abundance, more particularly in the West, and South.* It has been met with occasionally in New York, specimens having been received by me from ex-Governor Seymour, occurring upon his farm near Utica, and from others.

It has been suggested that this fungus attack might be extended, through propagation and distribution of the spores of the fungus, but I am not aware that the experiment has ever been made.

PREVENTIVES AND REMEDIES.

Passing now to the more practical portion of this paper, we will consider what may be done to control the ravages of the insect of which we have been speaking, and first, the preventive means that promise protection.

Ashes.—It is stated that for strawberries, which are very liable to attack, an efficient protection is found in placing a quantity of ashes, either leached or unleached, upon the ground, before setting the plants. This is upon the authority of Dr. Barnes, of Owasso, Mich.

Tobacco.— A gentleman from Westwood, N. J., states that by digging [burying] tobacco-stems into strawberry beds, the injury of the grub may be prevented (*Country Gentleman*, Oct 21, 1875, p. 669).

Rolling, etc.—Compacting the surface of the ground by treading it with sheep or cattle, or by the use of heavy rollers, might give protection from the deposit of eggs, by the inability of the beetle (if this be its habit) of excavating the earth for the purpose, and might also serve to prevent the easy passage of the grubs, if in the soil, from one root to another. But this method, which has been urged for use against many insects by English writers, seems so opposed to the condition of looseness and pulverization of the soil which is well known to stimulate vegetable growth, that we incline to the belief that whatever protection it might yield from insect injury would be counterbalanced by a stinted crop.

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* Mr. Wm. Trelease has found it proving very destructive to white grubs in the neighborhood of Madison, Wis. (*Psyche*, iii, 1881, p. 279).

Gas-lime.— Although not tested by experiment, I have great faith in the efficacy of gas-lime, as a protection from the deposit of the eggs of the beetle, or, if the protection be but partial, then, for the destruction of such eggs as may have been deposited. Upon ground to be seeded or planted, the lime, fresh from the works, might be distributed and worked into the soil, but where the crop to be protected is already upon the ground, the lime should first undergo such atmospheric exposure as would permit of its use as a top-dressing without harm to the vegetation. It should be applied during the month of May or June, or as soon as the beetles are seen upon the wing. For different methods of its application I would refer to my First Annual Report, where I have treated at some length of gas-lime as an insecticide.

In referring to this preventive, Miss Ormerod has written: "Gas-lime has been tried, sprinkled broadcast, without keeping off the chafers, but if it was shoveled on in a thin layer, so that the chafers could have no cognizance by any natural instinct of what was beneath, and also could not penetrate into the soil without first fairly scuffling their way through the gas-lime, one might hope for good results. It would be well worth while to try whether shoveling ashes or dry earth, well sprinkled with spirits of tar, or with phenol, might not be of great service; or again, mulching over the roots with any suitable material that could be moistened from time to time with soft (or whale oil) soap (*Agricultural Students' Gazette* [Cirencester, England], April, 1883, i, p. 73).

Air-slacked Lime.— There is good reason to believe, from the many statements that have been made, that the foliage of trees threatened by destruction from the beetle, may be saved by a thorough dusting of air-slacked lime above and below, as far as possible, while damp with the dew — better if done in the morning. The pests dislike gritty food, which is apparently repulsive to them, and while the greater part of the caustic quality of the lime thus slacked is gone through the slacking, yet doubtless there is enough remaining to make the taste of it obnoxious.

According to the *Livermore* (Cal.) *Herald*, Mr. Julius Schrader, who owns a fine vineyard and orchard west of that town, saved his crop of apricots from the attack of June bugs by the use of air-slacked lime. His trees were swarming with the insects, which had begun to destroy the fruit as fast as it ripened. He applied the lime by dusting it through the trees, with the result of driving away every insect, and saving the remainder of the crop uninjured. (D. W. Coquillet, in the *Pacific Fruit Grower*, i, September, 1887, p. 132).

Infusion of Burdock Leaves.—A correspondent of the *New England Homestead* gave the following as an effectual remedy for an attack of the onion maggot:

Take green burdock leaves and stalks, run them through a hay-cutter, put them in a large kettle or tub, and mash them with an old axe or mall, adding water, and pounding them to a pulp. Let it stand over night, have the decoction strong, and when you see the first sign of the maggot, use this, and it will be found a dead shot for the worm. Put it on all of the onions as a preventive. I have used it for forty years on onions. I use a sprinkler, taking off the nozzle, and pouring the solution along the rows. I seldom have to apply it the second time.

If the above was what it claimed to be—an effectual preventive of the attack of the persistent onion maggot, which no application hitherto had served to repel—it seemed that it should be equally efficient if used to prevent attack of the white grub. A test of its efficacy was, therefore, suggested to Professor C. H. Peck, who had applied to me for aid against the ravages of the white grubs in his garden. The results of its use by him were so entirely satisfactory, that a communication, in which they are detailed, made to the *Country Gentleman* of November 25, 1886, p. 893, c. 4, is herewith given:

EDITORS COUNTRY GENTLEMAN.—In April last the writer moved into the country, and started a garden. In one part of it, 300 strawberry plants were set. The ground had previously been in grass, and was well stocked with the white grub—the larva of the troublesome May-beetle, *Lachnosterna fusca.* Any experienced strawberry-grower would probably say that it was a foolish operation to set strawberry plants in such land, but as no other was available, the risk was taken, and the difficulties encountered. No sooner had the plants fairly commenced growing than they began to die, one after another. The withered and drying plants were found to be nearly rootless, and, in most instances, the white grub that had eaten the roots was found in the ground under the plants.

As a first attempt to stop the destruction, the earth between the rows of plants was dug over, and the grubs thus found (about forty) were killed. But all were not found. The destruction still went on, though perhaps less rapidly than before. Wetting the ground about some of the plants with chamber slops was tried, but proved ineffectual. At the suggestion of the State Entomologist, Prof. J. A. Lintner, the burdock remedy, which has been reported as effectual against the root maggots of the onion and cabbage, was tried. A bundle of burdock plants was gathered, cut and pounded according to directions, and soaked in water over night. With this infusion a dozen or more of the strawberry plants in different parts of the patch were watered. Under two of them, as special-test plants, living grubs were placed, that they might be in a convenient position to eat the burdock-watered roots, if they were so disposed. But they did not eat them, nor to this day have any of the plants thus treated at that time been attacked. After the lapse of about two weeks, wishing to see if the remedy was still effectual, another live grub was placed in the soil, at the roots of one of the special-test plants; but he, like his predecessors, declined the proffered roots. In the meantime, the untreated plants were dying, one after another, from the loss of their roots, till now nearly half the number have been destroyed.

But the experiment already tried had given me such confidence in the burdock remedy that the vacant places in the patch were filled with new plants, and these, together with the untreated older ones, were given a dose of burdock water. This put an end to the attacks of the white grub for at least six weeks. Then two of the late-set plants suddenly wilted, and were found to have their roots partly eaten. With this exception, no treated plants have been lost to this day. I am unable to explain the failure in the case of these two plants. Possibly they may not have received so thorough a wetting as the other plants. Notwithstanding their loss, my confidence in the ability of the burdock remedy to protect the strawberry plant against the white grub is unshaken. It may possibly be necessary to apply it twice in a season, but with the exception of these two plants, one application has been sufficient in this case. It does not appear to be at all detrimental to the growth or vigor of the plant.

We may pass now to remedial measures, and first those referring to the destruction of the beetle.

Tree-shaking.— The May-beetle has a habit in common with many other species of becoming gregarious, in times of its great abundance, when it assembles in multitudes for the night upon fruit trees. This habit permits of its destruction in large numbers, and the reduction of the following brood to the extent that its eggs have not at this time been deposited, by shaking them from the trees upon sheets spread underneath. Dr. Harris records, that in this way two pailfuls of beetles were collected on the first evening of the experiment — the number decreasing upon following evenings until the fifth, when only two beetles were to be found. He adds: "The best time, however, for shaking the trees * * * is in the morning, when the insects do not attempt to fly. They are most easily collected in a cloth spread under the trees to receive them when they fall, after which they should be thrown into boiling water to kill them, and may then be given as food to swine" (*Treat. Ins. Inj. Veg.*, 1862, p. 31).

Dr. Fitch, in referring to this remedy, gives the time in which the trees may be shaken with the best results, as between midnight and daylight, as would appear from the observations of Mr. Milo Ingalsbe, of South Hartford, Washington county, N. Y. "He had seventy plum trees and a number of cherry trees of the choicest varieties, which never gave fairer promise of an abundant yield than at that time. But a swarm of these May-beetles suddenly gathered upon the trees, many of them being then splendidly in bloom, and in two nights, the fifteenth and sixteenth of May, wholly stripped them of their foliage, so that many of them were as naked as in winter. With their humming notes, these beetles were flying about the trees every evening until about 10 o'clock, when they would settle in clusters of eight, ten, twenty or more, and would thus remain until daylight, when they would tumble down from the trees, flying but little, however, and hiding themselves wherever convenient to stay through the day (*Third Fitch Rept. Ins. N. Y.*, 1859, p. 54).

Attracting to Light.—The beetles, in their evening flights, are readily attracted to light, as is shown in the frequency with which they fly in at the open windows of our dwellings, public halls, churches, etc., in warm evenings, and the numbers that may be seen circling about the electric lights of our streets, or lying upon the pavements beneath, to which they have fallen. This well-known propensity of the beetle may be utilized to lure them to their destruction. If a lantern be placed above a vessel of water upon which two or three tablespoonfuls of kerosene has been poured, many of the beetles drawn to the light and striking against it will be thrown into the water and killed. Many other noxious insects may at the same time be killed by this method.

In our efforts to destroy the *larva*, we are met with several difficulties, of which these may be given:

1. Applications to the ground of sufficient strength to invariably kill the grub, of which several might be mentioned, would also be destructive to a growing crop.

2. The strongest applications that may with safety be applied, would be so impaired in strength in entering and penetrating the ground as to become inefficient at a moderate depth.*

3. The grub has the ability of withdrawing itself from the obnoxious application by burying itself deeper in the ground.

In consideration of the above and like difficulties, effort should be directed toward the discovery of some substance which will act upon the grub through other means than its exceeding strength. Should it be of such a character as simply to be repulsive to its taste, there is reason to believe that, rather than to feed upon roots that are saturated with it, it would die of starvation. In this manner, perhaps, may be found the reputed efficacy of the burdock infusion and of the application next to be noticed. Experiments in this direction are very desirable.

Salt.— The application of salt has been pronounced an effectual remedy, while it has also been said to be of no avail whatever. The remedy would be so simple, and withal so inexpensive, that the claim made for it should be tested by careful experiments. It is possible that the reputed success may have resulted from its employment in the year of the greatest ravages — that preceding the transformation to the beetle, for during this latter year (next after the application), the newly-hatched grub will have made so little progress in its growth that there would necessarily be a comparative immunity from its injury. On the other hand, the ascribed failure may have followed a too economical use of the cheap material — perhaps through fear of injury to the crop. A gentleman who strongly recommends this remedy, presumably from having thoroughly tested its value, deems it essential that the salt should be used in large quantity. He writes: "The great error with those who have used it with unsatisfactory results has been its scanty application. I can assure the reader that grass or potatoes will grow luxuriantly under an application of *one ton and a half per acre,* which quantity would be sure to result in the complete extermination, not only of the grub, but every other kind of worm, and prevent the scab and other excrescences which sometimes appear on potatoes, as well as preventing rot. A less quantity, say half [three-fourths of a ton], or even two or three barrels to the acre, though of course not as effectual, will accomplish much" (*Country Gentleman, for Aug.* 3, 1882, p. 601, c. 2).

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* Some of the Lachnosterna grubs ordinarily feed at a considerable depth. Thus the larvæ of *Polyphylla decemlineata* Say, has been found by Mr. Rivers at a depth of from one foot to two feet among the root-fibers of a coarse grass and roots of a Californian laurel, *Umbellularia Californica* (*Bull. Cala. Acad. Sci.*, 1886, ii, p. 69).

If the above testimony to the value of salt as a grub-killer shall be sustained by further experiment, I would strongly urge, in view of the periodic character of these attacks in localities, that the salt be applied *in the year of the abundant appearance* of the beetle, and preferably during the month of August or September, although no injury from the grub may be apparent. At this time the young grubs which are produced from the eggs deposited in June are within reach of the application, and may be killed far more readily than when they have attained additional powers of resistance in another year's growth.

Caustic Lime wash.— Mr. Daniel Batchelor, of Utica, N. Y., in a paper on "Lawns and Lawn Grasses," read before the Western New York Horticultural Society, at its annual meeting in January, 1885, in referring to the destructiveness of the white grub to the roots of grasses, states:

> Its presence is made known by the appearance, in patches, of dead and bleaching grasses, and then is the time to attack the depredator. My method has been to pierce the sod with a steel bar to the depth of about six inches, and to make the perforations the same distance apart. Into these holes I pour caustic lime wash from the spout of a watering pot, and the pulpy fellow is done for. After the lapse of a few days the denuded surface is thoroughly raked, and some lawn seed sown.

Rooting out by Swine.—The value of swine in freeing infested grass lands from the grub has often been urged, and we think is not overestimated. I believe that this remedy will prove successful, if good rooters be employed, when other methods fail. Dr. Fitch has written of it:

"I would recommend the placing of a temporary fence around that portion of the meadow or pasture which is so thronged with these grubs, thus for a while converting the patch into a hog pasture. The propensity of these animals for rooting and tearing up the turf, we are all aware, is for the very purpose of coming at and feeding upon the grubs and worms that are lurking therein; and who knows but that this rooting propensity, which has all along been complained of as being the most vicious and troublesome habit which belongs to swine, may after all turn out to be the most valuable and necessary to us of any of the habits with which they are endowed. I can not but think that these animals, confined upon a spot so overstocked with grubs, would in a short time ferret out and devour every one of them, leaving the soil cleansed, mellowed, manured and well prepared for being immediately laid down to grass again, or for receiving any other rotation of crops for which the proprietor may deem the spot best adapted."

Mr. Walsh, formerly State Entomologist of Illinois, had equally strong faith in the value of this method of overcoming the white-grub attack. After discoursing upon the great increase in the insect as observed in a few preceding years, its growing injury to young nurseries, and its violent irruption upon corn, which had formerly been exempt from it, he adds: "I suspect that the above phenomena are to be wholly or partially attributed to the introduction of improved breeds of hogs in the place of the old, slab-sided, long-nosed prairie-rooters, and to the passage of laws compelling people to keep their hogs under fence, instead of allowing them to run at large. * * * Within the last few years such laws have been very generally passed in the Western States. * * * Hence, I am inclined to infer that the presence of the white grub is often to be attributed to the absence of the hog."

Digging out.—When a valuable crop has been found, too late for other remedies, to be suffering from a severe attack of the grub, threatening its entire destruction, it has been saved by digging out the grubs by hand — popularly known as grubbing. In a pamphlet recently published by Mr. R. C. Haldane, upon the "Coffee Grub in Ceylon," the writer, in the discussion of several methods, states:

"When coffee is thoroughly attacked, I know of but one cure—*dig out the grub.* It is slow, weary work, but it pays. I gave my men small dagger-shaped wooden pegs, and a cocoanut shell. Another man brought a bucket round into which he emptied the shells, and then took the collected grubs and put them in a five-gallon drum of boiling water." By the above method from 100 to 150 grubs could be collected at each bush, and in one season (1882) twelve tons of coffee grubs were picked from a field, in Lindula, of eighty acres."

Without occupying more space in a review and discussion of various other methods that have been proposed for destroying the grub, I will refer to but one other, which I regard as an effectual one, wherever it may be resorted to:

Starvation.—As soon as the attack is discovered, upon the removal of the crop, collect and burn, as far as practicable, all the vegetable material upon which the larvæ could feed. If the ground has been cultivated for vegetables, gather all the stalks, stems, vines, etc., together with the roots, in piles, and burn them. If the land be in grass, after feeding as closely as possible, plow thoroughly, and follow during the autumn with such additional plowings and harrowings as shall best tend to destroy all vegetable life. At this time, gas-lime, if procurable, should be applied. Repeat these operations in the following spring, and allow the land to lie fallow for the year. Compliance with these directions would not only starve out the white grub, but also whatever wire-worms, cut-worms, and other underground larvæ there might be present.

The fallowing of the land for an entire year may be found to be unnecessary. It is not improbable that it might be preferable that the thorough breaking up of the ground in the autumn and spring be followed with a crop of buckwheat. Wonderful efficacy has been claimed for this plant, in freeing the ground from wire-worms—the larvæ of other beetles, and we know not why it may not be equally efficient when employed against the white grub. By all means, let thorough tests of its value be made, since the trial is so simple. Hon. A. B. Dickinson, after experimenting with salt and lime for destroying wire-worms, has stated: "I have only proved one remedy for the rascals, and that is, to break the sod and sow it to buckwheat; plow late and as often as possible in the fall, and then sow it to peas in the spring; with the like plowing next fall, they will not disturb any crop the next season."

In England, a crop of mustard is regarded as an antidote against the wire-worm. In an address before an agricultural society there, the speaker, after detailing some successful experiments upon a small scale with mustard, stated as follows: "Thus encouraged by these results, I sowed the next year a whole field of forty-two acres, which had never repaid me for nineteen years, in consequence of nearly every crop being destroyed by the wire-worm; and I am warranted in stating that *not a single wire-worm could be found the following year*, and the crop of wheat throughout was superior to any that I had grown for twenty-one years." Certainly this very successful experiment, confirmed as it is by many others that I find recorded, deserves to be faithfully tested with the white grub.

STUDY OF THE INSECT DESIRED.

I have now given the characters by which the notorious white grub may be recognized; have narrated so much of its life-history as is known to us; have told of its ravages and of the enemies that prey upon it; and, so far as I am able, have pointed out the principal means for the prevention of its depredations, indicating those which are deemed the best.

To me, and perhaps to many others, it is not the satisfactory exhibit of knowledge of the species that is desirable. As before stated, there are several points in its history upon which information is still needed. May I ask, and in return be favored with the aid of the farmers of our State toward supplying what is lacking? They have the opportunities for making valuable contributions with but little effort, and of a kind that may not be obtained from other sources. I would, therefore, beg of them, and of all others who are interested in the eminently practical work in which we are engaged, to make observation and to send me the results from time to time of some of the following points. Even in a communication of two or three lines, quite important information may be contained:

1. The earliest and the latest appearance of the May-beetle in any year.
2. The comparative abundance of the beetle in different years, particularly noting such years of unusual abundance, as may appear to indicate a periodicity of three years.
3. The presence or absence of eggs in the female beetle, to be ascertained by cutting open the abdomen and examining the contents. The female may be told by the three-leaved (when spread apart) terminal club of the antennæ being but about one-half the length of that of the male. My observations tend to the probability that the eggs are deposited before the beetle comes abroad for flight and food. It is important that this point should be determined.
4. The reëntering the ground (if so) by the female for depositing her eggs; the character of the soil entered as to its degree of compactness; and the crop cultivated thereon.
5. The manner of oviposition, if in a mass within a ball of earth as stated, or singly — the number of eggs, and depth at which placed.

It is thought that this can be ascertained the most easily by taking a few examples of each sex when freshly turned out from the ground while yet in their pale color, and confining them in a box of sod-covered earth, and, after their death, carefully examining the soil for the eggs that may have been deposited. Or the beetles uncovered by the plow in the early spring might be sent to the State Entomologist for his observation.

6. The effects of gas-tar water, ammoniacal liquid when it can be obtained, guano, phosphates and superphosphates, hog manure, kainit, sludge acid, alkali waste, bisulphide of carbon, etc., employed either as preventive of egg-deposit or for killing the larvæ. Even negative results from the use of any of the above applications should be recorded.

SPRING MANUAL OF PRACTICE IN ECONOMIC ZOOLOGY.

WHAT TO DO IN SPRING AGAINST THE MORE IMPORTANT INSECT PESTS OF THE FARM, ORCHARD AND GARDEN.

OHIO
Agricultural Experiment Station.

WOOSTER, OHIO, U. S. A., NOVEMBER, 1908.

BULLETIN 198

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OHIO AGRICULTURAL EXPERIMENT STATION.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 198. NOVEMBER, 1908.

SPRING PRACTICE IN ECONOMIC ZOOLOGY.

BY H. A. GOSSARD.

PREFACE.

THE present compilation is the second number of a series of Manuals of Economic Zoology, to be issued in four numbers corresponding to the four divisions of the year. The Winter Manual was issued in 1905; the Summer and Autumn compends will follow within the coming year. The present number is the most important one of the set.

The tables for general treatment of fruits have been made to cover the entire year, since it would be practically impossible to make them conform to exact time limitations. Professors Selby and Green have kindly assisted in preparing the tables from the standpoint of fungicides and practice, and these may therefore be regarded as summing up the best experience and knowledge of the Station officers. Practically the same matter is furnished in the spray calendar, the chief difference being that the tables are somewhat fuller from the entomological standpoint. For information concerning spray formulae, etc., see the spray calendar, Bulletin 199.

The time schedules assigned for work, and the appearance of the various insects, must be regarded as only approximate and subject to considerable variation because of weather conditions, latitude, etc. The periods of expected appearance for the insects mentioned will be found approximately accurate for central Ohio in average seasons. Southern Ohio should look for them a little earlier, and northern Ohio, a little later than the dates given. The

Manual is intended as a textbook of practice, and the writer believes that the time key will be useful to the agriculturist in forewarning him what to expect and look for in his fields and orchards. The ordinary type of manual is consulted "after the thief has entered the stable and stolen the horse" while it is hoped that the present arrangement will induce many farmers to look forward and see what enemies are to be expected in the weeks immediately ahead, and what efforts should be made to forestall them. Orders for insecticides, machinery, etc., can be planned accordingly. The experience of many years, and the accumulated reports of thousands of observers will be needed to furnish an accurate time schedule for such a manual, and we therefore solicit reports from our friends in the state, confirming or changing the schedule herewith tentatively offered. The facts set forth in the manual have been drawn from many sources. The writings of Saunders, Chittenden, Sanderson, Smith, Slingerland and Pettit have been frequently consulted, but I have also drawn freely from the writings of others. The publications of the U. S. Biological Survey have furnished valuable help. My thanks are also due to my efficient assistant, Mr. W. H. Goodwin, who has had full charge of all the illustrative work of the bulletin.

GENERAL MANAGEMENT.

INJURIES BY INSECT ENEMIES MAY BE ANTICIPATED AND PREVENTED.

Having decided what crops are to be grown for the year it will be worth the farmer's while to look through this Manual and by reference to the sections treating of these crops, see what pests are apt to attack them during the spring and if steps can be taken before planting time, at planting, or soon thereafter, to prevent or minimize anticipated injury. Such investigation may render a change of plans advisable at the outset and thus future annoyance and loss may be saved. After the crops are planted, consult the Manual at the beginning of each month and keep a lookout for such insects as are likely to cause trouble in the near future. Not only will this attention save loss from insects, but the growers determination to successfully carry his crops to maturity will be increased, and his interest in all other factors relating to their health and vigor will be stimulated. Again, the insects themselves will become creatures of interest because they are subjects of first-hand acquaintance.

ROTATION OF CROPS.

In the case of field and garden crops, not only is rotation necessary as a means for conserving soil fertility, but it is of the utmost importance as a means to control injurious insects and fungous diseases. It is unwise to grow the same specific crop for two successive years on the same soil, and it is even unwise to grow two different but closely related crops following each other; for example, rape or turnips should not follow cabbage, lest they be attacked by some of the various cabbage worms or by root maggots; also egg-plants or tomatoes after potatoes are apt to be attacked by flea-beetles. It is likewise bad practice to plant crops following each other that are badly attacked by the same insects, though the two crops are not closely related in a botanical sense. When the common STALK BORER, *Papaipema nitela*, is abundant in corn, it will in all probability destroy a crop of tomatoes immediately following the corn. All things considered, a systematic and regular rotation, properly planned, is probably the most effective means for controlling the majority of insect pests which attack field crops.

FERTILIZERS.

Plants that are badly attacked by insects can often be stimulated to outgrow the injury by a liberal application of fertilizer. From the entomological standpoint, commercial fertilizers are in many cases more desirable to use than barnyard manure; for instance, root maggots flourish in organic matter, but are discouraged or killed by such commercial fertilizers as kainit and nitrate of soda. As a matter of course, all soil, to produce well, must have a certain amount of humus in it and barnyard manure must sometimes be applied in liberal quantity. The increased vigor of plants growing in a well manured soil, generally more than counterbalances the damage caused by the greater number of insects which are sometimes thereby developed.

CLEAN FARMING.

CHINTZ BUGS, SQUASH BUGS, and hundreds of others hibernate in grass and weeds, or beneath rubbish, such as old boards, during winter, and may be destroyed in early spring by burning. Many insects feed upon common weeds in the spring before crops of value are planted or have appeared above ground. An illustration is found in the CORN ROOT LOUSE which feeds upon the roots of smartweed until the corn appears. The free use of the weeder in early spring is one of the preventives of insect damage. Whenever any crop has been harvested, grub out and destroy all remnants of stems, roots and leaves by burning, or by deeply burying them.

NATURAL FRIENDS AND ENEMIES.

DOMESTICATED ANIMALS AND BIRDS.

These will be considered only in the relation they sustain to insects, since this role in their lives is less comonly known, or at least is less appreciated, than their offices in supplying meats for human consumption, and assisting to maintain the fertility of the land and the like. CHICKENS and TURKEYS devour many caterpillars and other insect forms. They will often save the plum and peach crop from ruin by the curculio if they have free access to the orchard. On the other hand, they are liable to scatter scale insects over an orchard if they are allowed to roost in trees that are infested with scales. Chickens and turkeys may be taught to follow the plow in flocks and will pick up white grubs, cutworms, etc., in great numbers. The GUINEA FOWL is a most persistent and voracious insect hunter and, if allowed some freedom, is a much wider ranger than other domestic fowls. PIGEONS devour some insects and many weed seeds. Pigeon crops sometimes contain many of the pupae of the sheep tick which they have picked from the wool of living animals. DUCKS and GEESE also devour considerable numbers of insects.

HOGS are very useful in contending with white grubs and subterranean insects. If a sufficiently large herd of hogs can be turned loose into an infested field the fall before it is to be planted to a new crop, and continued therein until seeding time the next spring, they will do more than any other agency to insure a good harvest from such land.

WILD ANIMALS.

Rats: These animals may be destroyed by making a dough of barium carbonate, otherwise known as barytes, and oatmeal, one part by measure of barytes and eight parts of oatmeal being well mixed together and moistened sufficiently to make a stiff dough. Cornmeal may be used instead of oatmeal, or the barytes may be spread on bread and butter, or on moistened toast, or on cheese. Place the bait in the runways of the rats, a small bit in a place. This poison has neither taste nor smell and, in such small quantities as used for rodents, is comparatively harmless to larger animals. It acts somewhat slowly, but this is an advantage rather than not, since the sickened animals nearly always leave their burrows and die in the open when searching for water. The stench which would arise from the decaying bodies of the rats remaining in their holes is thereby avoided. If one application does not rid the premises of the pests, repeat the poison dose with a change of bait.

Dry strychnine crystals may be concealed in incisions made in bits of raw meat, or hidden in Vienna sausage, or in toasted cheese and thus scattered in rat runs, but this method is not advisable in human habitations, since the poison operates quickly and the carcases are almost certain to remain in the holes, often making an intolerable stench.

Oatmeal or cornmeal may be wet with a strychnine solution and scattered in the same way. This solution is made by dissolving one-half ounce of sulfate of strychnine in one pint of boiling water. One pint of thick sugar syrup is added and the mixture is well stirred. Use enough of this solution to moisten all the bait. Wheat soaked over night in the solution is sometimes used as a bait. If the animals are fed for one or two nights previous to baiting, on unpoisoned bait of the kind chosen for use, success will be made more certain.

Trapping is one of the best ways for controlling rats. Guillotine traps are best and may be baited with bacon or Vienna sausage (Wienerwurst). Other baits to use with traps are toasted cheese, toasted bread and butter, pumpkin seeds and oatmeal. Handle baits and traps as little as possible. If the hands are gloved with thick material, but little worn, and powerfully scented with aniseed, caraway, or other strong smelling substance, success is said to be more certain. After traps have been handled a good deal, they are improved by being smoked or smudged for a few moments.

Rats may be destroyed in their holes, when these are located in fields or along banks and roadsides, by fumigation with bisulfid of carbon.

The use of concrete cement for cellars, basements, foundations, barn floors, cisterns, etc., reduces suitable locations for burrows to a minimum, and damage by rats about buildings will largely cease when the use of this material has become widespread. Corn cribs may be protected against depredations of rats and mice by being lined with strong, fine-meshed wire netting.

Foxes, skunks, weasels, cats, dogs, owls and hawks destroy rats as opportunity offers. Ferrets and a pack of dogs, trained to work together by an experienced rat catcher, can accomplish much with a day's effort.

Mice: About dwellings, trapping is the preferable method of control. Traps and cats together are often sufficient to keep them subdued in barns and outbuildings, but these sometimes need to be supplemented with poison. The poison baits recommended for rats are equally good for mice. Field mice may be destroyed with the same baits, scattered under boards or similar shelters, away from the reach of valuable birds. Wide boards, with inch cross-pieces nailed under them, are suited for this purpose. Or pieces of drain tiles can be laid along the trails and the poison can be placed inside with a long handled spoon. Old tin cans, with their ends compressed, or with small openings in their ends, may be used instead of tile. In orchards and nurseries, the trees may be protected in early spring and in winter by cutting small twigs, such as the suckers from apple trees, dividing them into suitable short lengths, and dipping them into the strychnine syrup solution. These poisoned cuttings are scattered along the tree rows and are eaten by both mice and rabbits, while they do not endanger birds or other animals. Meadow mice devour many useless wild plants and weed seeds, but are certain to do much harm to orchard and nursery trees when snow is on the ground, especially if they are abundant. They also devour many insects, some injurious ones, and some valuable ones—such as the young of bumble bees, these latter insects being of much service to the producer of clover-seed. All things considered, we think it wise to destroy as many of these mice as possible.

Mechanical protectors are much used for young orchard trees. Cylinders of fine-meshed wire are valuable. Sections of corn stalks are sometimes packed and tied into cylinder form around the bases of the trees and give good satisfaction. Newspapers tied around the trunks, next to the ground, are of some value.

On a large scale, a thick Bordeaux mixture is said to be useful to the nurseryman. Make a thick white-wash, about the consistency of cream, to which add enough blue vitriol to give a "robin's egg blue" color. Paint on the trunks to a height of 18 to 24 inches or more.

Rabbits: I am assured by parties who have tested the remedy that young and succulent plants such as garden peas, cabbage, etc., of which rabbits are especially fond, may be protected by being dusted, while the dew is on in the morning, with dried blood, or dried blood and bone ground into a powder—the form commonly furnished by the fertilizer factories. Read the preceding paragraph on mice for additional information.

Moles: These little animals work altogether underground, feeding on earthworms, grubs, beetles, and a limited amount of vegetable matter. It seems certain that they do more good than harm, but because of their habit of injuring lawns and gardens, it is sometimes considered expedient to kill them. Their destruction is probably most readily accomplished by making use of a good mole trap, various patterns of which are offered on the market. Moles have particular periods of the day when they work most freely, and if their mounds are carefully and silently watched during their working hours, it is often possible to locate their exact whereabouts. By means of a quick, strong thrust it is possible to fling a shovel blade beneath the creature at the moment the movement in the mound is observed, and throw it with the loose earth to the top of the ground. Or a many-tined fork may be flung into the earth with full force, when the movement is observed, and the mole will probably be impaled on the fork. A light charge of shot fired into the mound, coincidentally with the movement, would be almost certain to kill the animal. Use but little powder for such an attempt.

Shrews: These little animals are generally mistaken for mice, and one species with a burrowing habit is usually confounded with the moles. The mole shrew is of rather stout build, tail about one inch long and it possesses short legs and a pointed nose. The fur is very fine and glossy, the eyes very small, the ears almost imperceptible, and hidden in the fur. The front feet of the burrowing shrew are slightly enlarged for digging, but are widely different from the expanded flippers of the mole. The front and hind feet of most shrews are like those of mice. The mole shrew is a common Ohio species. It makes underground runways that show as elevated ridges on the surface of the ground in gardens and lawns, but does not make the characteristic mounds or mole-hills of the true mole. The shrews are on the whole very beneficial to the agriculturist and deserve protection. Some live almost entirely above ground, and even the mole shrew spends a good part of its life above ground. A single shrew will destroy hundreds of young meadow mice in a season, if opportunity offers. Young rats are also devoured by it, and it has the reputation of being able to overcome creatures larger than itself. Shrews also eat great numbers of earthworms, sowbugs, slugs, white grubs, grasshoppers, ground beetles and other insects. When the mole shrew becomes too plentiful in lawns and gardens, it can probably be killed by strychnine inserted into bits of meat which are put into the freshly-made burrows; but it is questionable if this creature should be interfered with, even under these annoying circumstances.

Skunks: These animals, like the shrews, are among the farmer's very best friends. While an occasional individual takes a liking to young poultry, and should then be destroyed, the great majority do not molest the chicken yard, but do consume an enormous number of June beetles, white grubs, grasshoppers, crickets, field-mice, etc. This creature is probably the most valuable animal in existence for controlling the white grub. It devours both beetles and larvae greedily. Its good offices are partially counterbalanced by the destruction of the eggs and young of valuable birds, also of young rabbits and young shrews whenever opportunity offers. We can spare the rabbits without much, if any loss, and on the whole, the skunk deserves protection.

Woodchucks: These are vegetable feeders, living on garden products, fruits and tender pasture grass. They are, generally speaking, injurious, and possess no specially beneficial traits. They may be caught in strong steel traps or killed by a charge of buckshot from a close, hard-shooting gun. The skin is very thick and tough and it is useless to attempt to kill them with small shot, or a light load.

A large wad of rags or of cotton may be saturated with bisulfid of carbon and pushed into the animal's burrow, the opening being closed with a stone or chunk of wood, over which loose earth is shoveled to shut in the fumes. All openings to the burrow, except the one used for fumigating, should be closed before the gas is used. It requires only a few minutes of fumigation to kill the woodchuck in the burrow.

The Toad: The toad is a very valuable friend, especially to the gardener. Toads live for several years and by preference remain on the same feeding grounds from year to year. About 98 percent of the toad's food consists of animal matter. Among the forms regularly eaten are angle worms, snails, sowbugs, thousand-legged worms, spiders, ants, grasshoppers, crickets, cutworms, beetles and various caterpillars. From 60 to 80 percent of injurious insects and a small percent of beneficial insects go in with its customary ration. The stomach is filled and emptied about four times in each 24 hours. Upon the basis of stomach examinations, it has been estimated that during the 90-day period extending over May, June and July, a grown toad will consume 2160 cutworms, 1800 myriapods or thousand-legged worms, 2160 sowbugs, 3240 ants, 360 weevils, and 360 ground beetles, the last being beneficial insects. The sum total, therefore, for the 90 days, is 360 beneficial insects and 9720 injurious ones destroyed. Mr. A. H. Kirkland, who made the foregoing computations, observes that children are often paid one cent for each cutworm they kill, and that on this basis, after allowing ten percent deduction from the total number consumed, to offset the probable number that would have been killed by the devoured ground beetles, we still have 1944 cutworms to the toad's credit, or in money value it is worth $19.44 in 3 months time. English and French gardeners appreciate the value of toads and as high as $25 per hundred is said to be often paid for them. Owing to the dislike of the creatures for new and unfamiliar surroundings, it is advisable in many cases to provide a breeding pool for them in order that the young may establish themselves where they are wanted. A shallow pool of cement, having a small but constant water supply is sufficient, and the old toads should be carried to it at mating time, which in this latitude comes in April and May. Stagnant water is better than running water from the standpoint of the toad raiser. The young toads will leave the water by midsummer, or before mosquitoes become abundant, and the pool should then be drained to prevent mosquito breeding. A small indoor aquarim, protected from mosquitos by screens, may prove more satisfactory than an outdoor pool. Supply with fresh-water plants and clams, and feed the creatures with bits of dog biscuit or chopped fresh meat as needed. Do not feed more of any food than the toads and tadpoles will consume, or the water will become contaminated. The outdoor pool can be screened against mosquitoes, if desired, provided the toads are fed.

For garden shelters, make shallow holes in the ground and cover with flat stones or boards. The toads will retire into these in the daytime and come forth at dusk for their nightly forays. Toads are specially valuable to greenhouse men, keeping down slugs, snails, sowbugs thousand-legged worms, plant lice, cutworms, etc.

PLATE I.

A Garden Toad. The Gardener's Friend.

Photo by Goodwin.

BIRDS.

Want of space prevents any adequate treatment of these important allies of the farmer. Farmer's Bulletin No. 54 on "Some Common Birds in their Relation to Agriculture," may be obtained from the U. S. Department of Agriculture and gives much valuable information. Weed and Dearborn's "Birds in their Relation to Man," (J. B. Lippincott Co., Philadelphia) is a very valuable work from the economic standpoint.

The following notes upon some of our common birds and bird groups gives some meager information regarding their usefulness:

Quail: A great feeder upon weed seed of all kinds. Over 60 percent of its food is weed seed. It devours great quantities of the seeds of ragweed, pigweed, sheep sorrel, paspalum, jewell weed, pigeon grass, etc. The stomachs and crops of 13 birds, shot and examined by the U. S. Biological Survey, contained, even though only partially filled, 5,582 weed seeds. One crop contained 400 pigweed seeds, a second 200 seeds of ragweed, a third 620 seeds of pigeon grass, and a fourth 550 seeds of sheep sorrel. It also eats freely of our worst insect pests, grasshoppers, chinch bugs, Colorado potato beetles, striped cucumber beetles, May beetles, army worms, cutworms, etc. A more valuable bird does not live on the farm.

Mourning Dove: As a weed consumer it has habits similar to the quail, but eats few or no insects.

Cuckoos: Great feeders upon caterpillars, devouring hairy ones as well as smooth ones. The tent-caterpillars and fall webworms, which are usually shunned by other birds because of their hairiness, are greedily eaten by the cuckoo or rain crow. Stink bugs, grasshoppers, beetles and spiders are also eaten.

Crow: This bird devours grasshoppers, cutworms, May beetles, caterpillars, frogs, toads, snakes, eggs of all kinds, young birds including young chickens, mice, crayfishes, snails, some grain and also a little fruit. It has the mischievious habit of pulling up sprouting corn, also of eating green corn ears while "in the milk."

Some one or more of the following methods may be tried to protect seed corn from crows:

1 "Tar the seed corn as follows: Put one-fourth to one-half bushel of corn in a half-barrel tub; pour on a pailful of hot water, or as much as is necessary to well cover the corn; dip a stick in gas tar and stir this briskly in the corn; repeat until the corn is entirely black; pour off onto burlap (bran sacks are excellent); spread in the sun and stir two or three times during the day. If this work is done in the morning and the day is sunny, the corn will be ready for the

planter the next day without any other care. The hot water softens the tar so that just enough adheres to the corn, and the corn is completely glazed by the sun. This is by far the quicker way of tarring corn, is harmless and effectual, and I have for years planted with a machine corn treated in this way."*

2 "Scatter soaked corn often about the borders of the field."

3 "Plant the seed three or four inches deep. This is said to prevent corn-pulling by crows and must be effectual on heavy soil."

4 "Surround the field with a line of twine, strung on upright poles, and suspend rags, streamers, pieces of bright tin, etc., from the twine."

5 "A frequent change in scarecrows is advisable. A barrel hung on a leaning pole puzzles the crow."†

6 A crow can sometimes be coaxed into a steel trap. An egg is so exposed that the bird can only obtain it by stepping into the trap, which is carefully concealed under loose earth. One or two dead crows procured by this or any other method will usually keep the others away for one season.

7 A long range rifle, fired from concealment, will make the birds wary of the neighborhood, especially if one or two are killed and hung up in the field.

Robin: A few birds remain in Ohio during the winter, but in general the robin is migratory and it is one of the early comers northward in spring. Over 42 percent of its food is animal matter, principally insects, while the remainder is largely made up of small fruits and berries. Of the 58 percent of vegetable food, over 47 percent consists of wild fruits, and a little more than four percent of the cultivated varieties. During June and July, the percentage of cultivated fruit rises to 25 percent, but in view of the great service the bird renders throughout the year, we can well afford it a share in the cherry and small fruit crop. Grasshoppers make up one-tenth of the food and in August constitute over 30 percent.

The Russian mulberry ripens about the same time as cherries, and mulberries are preferred by robins and most other fruit loving birds before the commonly cultivated fruits. Therefore, the fruit-grower should plant a mulberry here and there over his plantation.

Meadowlark: Grasshoppers make up 29 percent of its food for the year and comprise 69 percent of it in August. About 21 percent consists of beetles, two-thirds of which are harmful. Caterpillars, cutworms, ants, chinch bugs, wasps, etc., bring up the total percentage of insect food for the year to 73 percent. The 27 percent of vegetable matter is about one-half grain and the other half weed seed. Most of the grain consumed is waste grain left in the field. This is a very useful bird, with no serious faults of any kind.

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* Ethan Brooks in An. Rept. Mass. State Board of Agric., 1896.

† E. H. Forbush in "Useful Birds and Their Protection," Mass. Board of Agric., 1907.

Woodpeckers: These birds perform a service to mankind for which no other creatures are adapted. They are, before all other birds, the conservators of the forest and orchard. Those insects, which because of their insidious habits, are beyond the discovery of other birds, and generally of man himself, constitute the common prey of the woodpeckers. Bark-borers and borers into the heart-wood, insects which strike for the vitals of the tree, are diligently sought for, winter and summer, by these birds. The ants, which burrow into decaying wood and thus extend and expose a greater surface to decay, are also eaten in large quantity. There is one disreputable member in the family, which puts the whole group under suspicion with people who do not carefully discriminate. This is the villanous **Sapsucker**, or **Yellow-bellied Woodpecker**, which makes rows of punctures in horizontal or spiral series in the bark of many trees. These punctures extend into the cambium or sapwood and when they become filled with sap are sucked dry by the bird. So many of these punctures are often made upon a tree that the effect is that of girdling it, and the tree dies. Sugar maples and coniferous evergreens are favorite objects of attack, but orchard and forest trees suffer also. While the bird eats a good many insects, I believe the shot-gun should be used whenever it is found to be attacking valuable trees.

Warblers and Vireos: The last week in April and the first week in May, for the southern and the northern parts of the state respectively, usually see the warblers migrating from their southern winter resorts to their Canadian breeding grounds. The vireos come at the same time, some of these remaining as summer residents. The following quotation from Dr. Elliott Coues gives a good idea of the activities of both groups, which possess similar habits:

"With tireless industry do the warblers befriend the human race. Their unconscious zeal plays due part in the nice adjustment of nature's forces, helping to bring about that balance of vegetable and insect life without which agriculture would be in vain. They visit the orchard when the apple and pear, the plum and cherry are in bloom, seeming to revel carelessly amid the sweet-scented and delicately tinted blossoms, but never faltering in their good work. They peer into the crevices of the bark, scrutinize each leaf, and explore the very heart of the buds to detect, drag forth, and destroy these tiny creatures, singly insignificant, collectively a scourge, which prey upon the hopes of the fruit grower, and which, if undisturbed, would bring his care to naught."

Orchard plant lice, which are just beginning to appear in force in early May, are devoured in great numbers by warblers and vireos.

Sparrows, Finches, Buntings and Grosbeaks: Usually small and sober colored birds, nearly all of which are valuable. Weed seed and insects make up the bulk of the food for the majority of these species. The **Pine Grosbeak** and the **Purple Finch** feed upon the buds of orchard and forest trees, but probably compensate for the damage in generous measure by their consumption of insects and weed seed. The **English Sparrow** is the most questionable member of the family. This bird destroys the buds and blossoms of fruit and shade trees, eats largely of grain and cultivated fruit, and drives our native birds away from their nesting places, taking pains also to annoy the latter on all possible occasions. They feed their young with a large proportion of insect food, but are not desirable neighbors, all things considered. One method of fighting them is to allow them to take possession of the boxes and nests that have been prepared for other birds, and then periodically destroy their eggs before any have time to hatch. After a year or two of this treatment they are glad to leave the nests to the more valuable natives. Poisoned wheat may be used for their destruction, but care must be taken not to expose it for other birds, and it must therefore be sown in small quantities where the sparrows will find it and devour all of it. Prepare the wheat as follows: Dissolve two drams of strychnine in three quarts of boiling hot water and keep boiling until the poison is all dissolved. Stir a peck of wheat into the water and allow to stand for 48 hours. Then spread the swelled grain over the bottom of a pan or in paper plates and allow to dry in the oven of a hot stove, stirring the while to prevent scorching. The birds will not eat scorched grain. Snowy, cold weather is the best time for spreading the bait.

Orioles, Blackbirds and Jays: The **Orioles** are very valuable insectivorous birds. Blackbirds are also of value. Even the **Crow Blackbird or Bronzed Grackle** does far more good than harm, 48 percent of its food consisting of animal matter, chiefly insects. The **Red-winged Blackbird** eats insects to the extent of 26 percent of its food. Weed seed comprises 57 percent and grain 13 percent. The **Blue Jay** eats nuts (acorns, chestnuts, etc.,) to the extent of about 42 percent of its food, devours considerable grain, also the eggs and young of smaller birds, and insects to the amount of 19 percent of its food. Owing to the harm it does to other birds, it is probably more injurious than beneficial. The **Bobolink** is a valuable bird in the north, subsisting almost wholly on insects and weed-seed; but in the south it is a scourge to the rice growers.

Fly Catchers, Swifts, Night-Hawks and Humming Birds: All of these are valuable. Most of them catch their food while flying through the air. Over 93 percent of the food of the **Phoebe or Pewee** consists of insects, the **Kingbird** includes 90 percent of insects in its menu, and the percentages eaten by the **Night-Hawk** and the **Whip-poor-will** are very similar.

Shrikes, Swallows, Waxwings and Tanagers: The **Shrikes** are valuable as mouse-killers and, while they butcher some beneficial birds, their beneficial qualities are estimated by good authorities to outway four to one their injurious ones. All the **Swallows** are beneficial. The **Purple Martin** is especially valuable, and will nest in boxes provided for it near human dwellings. The **Waxwings or Cedar Birds** are valuable, on the whole, though they sometimes eat cultivated fruits. The **Tangers** eat both insects and fruit, chiefly wild berries.

HOW TO ATTRACT THE BIRDS.

In spring far-reaching plans, which look a decade or more into the future for their full consumation, may be laid for the encouragement of bird increase. Plant here and there over the farm, near the house and near the orchard, clumps of trees from one-eighth to one-fourth acre in extent, consisting of evergreens, pines, spruces, firs and hardwoods intermingled. These will furnish winter retreats and summer nesting places. Scatter among such clumps, and also at other points on the farm, such trees as the Russian mulberry and the choke cherry to supply enticing food for the birds. Other trees, shrubs and vines, the fruit of which is inviting to birds are Juneberry, dogwood, mountain ash, juniper, hawthorn, elder, viburnum, barberry, wild plum, blackberry, cherry, raspberry, wild grape, catbrier, sumach, hackberry, shad-bush, honey-suckle, wax myrtle, etc. Plant a variety of these so as to furnish a succession of ripened berries for all periods of the year. Also a variety is needed to encourage nesting. Certain species prefer particular kinds of trees for nesting. Thus, the Baltimore orioles prefer elms; the goldfinch, and the warbling vireo, maples; the brown thrasher and catbird, thorny tangles of shrubbery, etc.

In the spring, before the summer rush of work comes on, is also a convenient time to put up a goodly number of bird houses about the farmstead, in the woods, and in the orchard. The floor space for these houses should be about 6x6 inches, and several such compartments may be bunched together into a colony house or "tenement" for such birds as martins, tree swallows, and pigeons. The doorway should never be made larger than necessary to admit the bird. Make a perch or doorstep below each door. A wooden pin driven into an auger hole makes a good perch. Martins and tree-swallows like to nest 26 feet or more above the ground, but other birds usually prefer an elevation of less than 12 feet. Houses made of weather-beaten boards are more attractive to birds than new or painted ones. If the English sparrows appropriate the boxes, allow them to lay their eggs and then destroy every egg before it hatches. After a year or two of this treatment the boxes will be left to their more valuable neighbors. Protect the houses from cats by running a close spiral of barbed wire around the trees or poles which sustain the houses, fastening the wire in position with staples. Gourds with one side cut away to make a door, and hollowed out, may be swung from tree limbs or telephone poles and make attractive houses for several species of birds. Place the houses where they will be shaded from the beating rays of the sun and protect the entrance against dashing rains.

At nest-building time, robins, swallows and phoebes will much appreciate a box of clay mud, placed within easy access, which is well wetted with water two or three times per day. Orioles, cedar birds and kingbirds will pick up bits of yarn put on limbs of trees or fences for them. Woolen strips cut from discarded clothing will be gladly utilized by some species. Make all such strips not more than 10 or 12 inches long. The following list of materials comprises those that are most utilized by various birds for nest construction: rootlets, hair from horses and cows, bits of birch bark, bits of newspaper, straw, fine hay, feathers, thread, twine, cedar or grapevine bark, rope yarn, mud, and sphagnum moss. Put these where the birds have access to them.

Arrange a bathing and drinking place near the house and also, if convenient, in the orchard and in the garden. Arrange the bath so the birds will not be exposed to attack by cats and hawks while indulging themselves. A shallow pan set on the window shelf or on a post on the shady side of the house, or in the shade of a tree at an elevation of four or five feet from the ground, will be satisfactory. A shelving stone should be put in the pan to give varying depths of water from one-half inch to two inches. Where running water is available, a drinking fountain may be constructed on a similar plan, always taking care to have some shallow water and to have the approaches to the spring so open to the view from all sides that the birds can readily detect the approach of danger. Tall weeds and grass should not be allowed to grow around springs and pools, not elevated above the surface of the ground, else lurking cats are almost certain to waylay many helpless birds while their feathers are wet. If filled pans are used, the water should be changed every day.

EXPLANATION OF PLATE II.

a Chestnut sided warbler. One of the friends of the orchardist.

b Bluebird home. One of the methods of encouraging useful birds to nest in the orchard.

Negative by Houser

a
b

The more serious enemies of birds should be discouraged, especially at breeding time. Hawks, crows, jays, squirrels and cats need to be shot in nearly every case where they are found to be molesting valuable birds.

MIGRATION RECORDS OF BIRDS.

In the Appendix, pp. i-v, are given the dates on which a large number of our feathered friends have been observed at Wooster, and by reference to it, the reader can readily determine what species of birds he is likely to encounter at any time in spring.

INSECT PARASITES AND DISEASES OF INSECTS.

Were it not that the insect household is divided against itself, parasitic and predaceous forms constantly destroying both near and distant kindred, all vegetation would be consumed in a few months and the human race would as quickly perish. Bacterial and fungous diseases are often exceedingly important checks upon the excessive multiplication of insects. A good Manual of Economic Entomology, such as Smith's (published by J. B. Lippincott Co., Philadelphia), will give valuable assistance in recognizing such helpers.

FARM TREATMENT.

INSECTS INJURIOUS TO VARIOUS GRASSES AND GRAINS.

MARCH--APRIL.

The CHINCH BUG, *Blissus leucopterus*, hibernates during winter under old boards and rubbish or in trash or grass around the borders of old fields, especially wheat fields. Such borders should be carefully burned over in very early spring in infested districts if such work was neglected in fall and winter.

GRASSHOPPERS lay their eggs in compact ground, especially along roadsides and in the uncultivated borders of fields. Bare, high, sandy ground and closely grazed pasture land, is especially resorted to for egg-laying. The eggs are laid in the fall in masses of about thirty, about an inch beneath the surface of the ground, in pod-like cavities. Disking the land in early spring before hatching time will destroy most of the eggs. The young hatch from about the middle of April to the middle of May in Ohio, depending upon the forwardness or the backwardness of the season. The young nymphs may be be poisoned with bran mash, (see p. 78) or oftentimes destroyed by burning. If the stubble or rubbish on the ground is insufficient to burn, scatter straw over the field and on cool days, when the insects have crept beneath it for shelter, set on fire. If the surface of the ground is level, a heavy roller run over it will crush many of the nymphs, especially on cool days or in the morning and evening.

When the nymphs are very numerous over large areas it is best to resort to ditching. The ditches are made two feet wide and two feet deep, with vertical sides. The sides next to the field to be protected must be kept finely pulverized and not allowed to become washed out or hardened. The right condition may be kept by dragging a brush composed of dead branches through the ditch as often as necessary. Pits should be sunk in the bottom of the ditch at short intervals in which the insects will accumulate, where they can easily be buried. Where it is possible to flood the ditches with water, the water may be covered with a film of coal oil, and the insects can be rapidly and certainly destroyed by being driven into the ditches.

The hopperdozer, much used in the northwest to destroy the nymphs, consists of a shallow receptacle of any convenient size, furnished with high back and sides, mounted either on wheels or runners. Large pans are provided with transverse partitions which prevent slopping of the water and oil when the machine catches a jar. The pans are filled with water and coal oil or gas tar, and are then pushed by hand or horse power over the infested fields, a set of shafts and handles being so arranged that the front edge of the pan can be elevated or depressed at will to adjust it to the jumps of the nymphs. A suggested form for operation by hand power is made of ordinary sheet iron eight feet long, eleven inches wide at the bottom, and turned up a foot high in the back, and an inch high in front. A runner extending some distance behind is placed at each end and a cord is attached to each front corner. This may be drawn by two boys. With more hands, several dozers may be placed end to end in a row, one man holding the cords of each pair of continuous ends, and thus the work may be done rapidly and well.

WHEAT INSECTS.

MARCH--APRIL.

The WHEAT JOINT WORM, *Isosoma tritici*, is carried over in the straw or stubble of the preceding year. In sections where winter wheat is grown, if care was not taken the preceding fall to sow as far as possible from the infested stubble fields, the best remedy where it can be applied is to burn the stubble. Where the wheat was sown as a nurse crop for grass and, therefore, the stubble cannot be burned, it may be worth while to rake over the field with a hayrake so as to remove part of the stubble, which may be burned. Badly infested straw remaining unused should be burned by the last of March so as to prevent any adults escaping to growing fields. Straw that has been well tramped by live stock and has been heated several weeks by passing through the manure heap, is probably safe enough to scatter over fields in spring, especially if they are distant from the wheat field; but comparatively fresh straw that has undergone but little change since leaving the stack, although it has passed through the manure heap, is too questionable to spread on lands that are near wheat fields. Such green manure, if containing larvae or pupae, should be left in the manure heap for a longer time.

If young wheat looks very sickly in spring, examine it carefully for indications of the HESSIAN FLY, *Mayetiola destructor*. The shining, brownish pupae, closely resembling flaxseeds, may be found beneath the culms at the bases of the plants. If they are very numerous in April, and a large percentage of the plants died during the winter from injury inflicted by them, it is sometimes best to plow the infested field under deeply and plant to some other crop.

CORN INSECTS.

APRIL--MAY.

The WESTERN CORN ROOT WORM, *Diabrotica longicornis*, is readily controlled by rotation of crops. Do not follow corn with corn, and do not plant corn in fields where the adult beetles were observed in exceptional abundance on weeds and clover, the preceding year. The beetle is about one-fifth of an inch in length and of a uniform pale-green or grass-green color. A well fertilized soil and thorough cultivation will do much to enable plants to outgrow damage to the corn roots.

Preventive measures for the SOUTHERN CORN ROOT WORM, *Diabrotica 12-punctata*, are the same as for the preceding species. Late planting also helps protect against this species. Planting a sufficiently large number of grains in a hill to feed the larvae and leave a good stand besides is sometimes practiced. Most grains and vegetables except beans and cucurbits, may be rotated with corn in badly infested districts. The beetle is generally mistaken for a ladybug, being of similar appearance, a trifle over one-fourth inch long, yellowish green in color, the wing covers marked with 12 black spots.

The SEED CORN MAGGOT, *Pegomya fuscíceps* Zett, is more important as a vegetable insect than as a corn pest. (See page 80.) In case it becomes destructive to corn, rotate the crops and use an excess of seed.

The Corn Root Aphis, *Aphis maidi-radicus*, may be greatly reduced in numbers by frequently stirring the ground between plowing and planting. This may be accomplished with a disk-harrow or a cultivator. This operation destroys many of the ants which foster the lice, by breaking up their nests, and kills many of the young of both ants and lice. Fertilizing well with barnyard manure also does much to fortify the corn against damage by the lice. Dr. Forbes, of the Illinois Station, reports promising results by treating the seed corn with a mixture of oil of lemon and wood alcohol. One gallon of wood alcohol is combined with one pint of oil of lemon, and three fluid ounces or six tablespoonsful of this mixture is sprinkled into each gallon of seed before planting. The corn is thoroughly stirred while being sprinkled to insure an equal distribution of the fluid and to make sure that each kernel of corn has its proper share. The odor of this mixture persists for weeks after the corn is buried, and owing to its repelling powers the cornfield ant will not enter corn hills until all odor has gone; consequently no aphis eggs are carried into the hills. Cost of materials is not over 10 cents per acre.

Cutworms may be destroyed with the poisoned bran bait. (See page 78.) This treatment has been tested on a large scale in the Canadian provinces and proved to be practical and successful. Cost, including labor of making the application, should not exceed one dollar per acre.

The Corn Root Web Worm, *Crambus caliginosellus*, and allied species, often damage young corn by burrowing into the base of the stalks. The larvae live in fine, loose, silken webs or cases, about an inch below the surface of the ground. These insects are normally grass feeders and rarely injure corn to a serious extent, except where planted on sod land. If there is reason to suppose them abundant on new land, plant to potatoes, buckwheat or some other crop than corn.

CLOVER INSECTS.

APRIL--MAY.

The larva of the Clover Seed Midge, *Cecidomyia leguminicola*, a small, reddish maggot which feeds in the florets, is often a cause of failure to mature a crop of seed. One method of dodging its effects is to pasture the clover during the spring months until about the middle of June, when the live stock is removed and a late crop of seed is generally obtained. There are two broods of the midge, one appearing about the middle of June, the second and smaller one in July and August. If the plants are kept eaten down in spring so that no June brood matures, because of the lack of blossoms on which to feed, the second or late brood will do very little damage.

EXPLANATION OF PLATE III.

a The Hessian fly. In flaxseed stage at base of stalk.
Negative by Houser

b Joint worm in wheat straw.
Photo by Goodwin.

c Joint worm larvae, enlarged.
Photo by Goodwin.

d Straws injured by joint worm showing enlargement and woody portions just above the joints.
Photo by Goodwin

a
b
c

The CLOVER SEED CATERPILLAR, *Grapholitha interstinctana*, also, feeds upon the florets, when they appear, as well as in the crowns of the plants near the earth in spring. Pasturage will likewise tend to diminish injury by this pest in spring.

The yellowish green, slug-like larvae of the CLOVER LEAF WEEVIL *Phytonomous punctatus*, begin feeding on the leaves of clover very early in spring and continue until they attain full growth in May and June. Beginning at the edge of a leaf the larva eats out a segment bounded by a regularly curved line. Sometimes smaller areas are eaten from the interior parts of the leaflets. When full grown the larvae construct very delicate cocoons of a greenish-yellow color on the surface of the ground. A fungous disease does much to control this species. The larvae in great numbers, just about the time they are grown, curve themselves around a spear of grass or over the edge of a leaflet and die, becoming covered with a white mold and later turning to a jelly-like consistency, eventually drying out to a small black mass entirely unrecognizable to the unfamiliar eye.

TOBACCO INSECTS.

APRIL--MAY.

CUTWORMS: Grass or clover sod that is to be planted to tobacco generally needs special attention to destroy cutworms before the tobacco is set out. Thorough cultivation in the spring, before planting, so as to deprive the worms of food, will help. If the poisoned bran mash (See page 78) is scattered over the land, a tablespoonful near each hill several days before the crop is planted, the majority of the worms will be killed before they have the opportunity of doing harm.

TOBACCO STALK WORM OR SOD WEB WORM: This insect, *Crambus caliginosellus*, commonly known as the CORN ROOT WEB WORM burrows into the stalks of newly set tobacco, sometimes destroying as many as three successive plantings of tobacco over the same ground. Where these worms are known to abound, do not plant tobacco after grass or timothy. Instead, follow with wheat and then clover before tobacco. If tobacco must follow grass at once, plow as early as possible, then roll and harrow at frequent intervals to starve out the worms before planting, which should be delayed as long as the season will permit.

TOBACCO FLEA BEETLE: This very small beetle, *Epitrix parvula* Fab., is of a light brown color, with a dark band transversely across the wing covers. It has the power of leaping like a flea. When numerous, they eat the leaves full of very small holes. Spray with weak Bordeaux mixture combined with arsenate of lead.

ORCHARD TREATMENT.

APPLE INSECTS.

MARCH.

About the first of March in ordinary seasons, or a trifle earlier in forward ones, the female moths of the SPRING CANKER WORM, *Paleacrita vernata*, issue from the ground and crawl up the trees to deposit their eggs. These females are wingless and may be intercepted in their ascent of the trunks and destroyed by tens of thousands by placing a sticky girdle around the trees from one to three feet above the ground. Bands of burlap painted over with coal tar, or printers ink, will serve the purpose, if painting is renewed often enough to keep the bands sticky. Tree tanglefoot, made by the O. & W. Thum Co., Grand Rapids, Mich., is a preparation designed especially for banding trees, and is applied directly to the bark with a brush. It remains sticky for months. Or strips of wire screening, four inches wide and of sufficient length to overlap a few inches after encircling the tree, may be used. A girdle of cotton batting is put around the tree, and the bottom of the band of wire netting is then tied tightly over the cotton ring by means of baling wire or stout cord. The top of the wire collar is now bent down over its fastening so as to give a downward and outward flare. But few of the moths will succeed in passing this collar. Orchards that are regularly sprayed for codling worm rarely, if ever, need banding. Directions for spraying for canker worm are given in operations for April.

SAN JOSE SCALE, *Aspidiotus perniciosus*, may be treated with the lime-sulphur spray up to the time the buds are unfolding in March and April. It is often impracticable to make an application earlier than late March because of freezing weather. In our practice, thus far, we have secured somewhat better results with spring applications than with those given at other periods. Sometimes it happens that the insect is present in an orchard but remains undiscovered or unrecognized until after the trees are in full leaf. In such case, probably the best course to pursue is to paint the trunks and as much as possible of the larger limbs with lime-sulphur spray, using a brush. The tops may be sprayed in June, at hatching time, with soluble oil or kerosene emulsion. By this means the trees may be enabled to withstand injuries which might otherwise prove fatal, until the following winter and spring, when they can be properly sprayed.

APRIL.

The BUD WORM, *Tmetocera ocellana*, enters the buds of apples and other fruit trees in early spring, just when they begin to swell and open, frequently cutting off terminal growth and injuring the fruit crop by destruction of the bloom buds. Later, the caterpillars tie the leaves together, forming conspicuous nests. As soon as the leaf tips appear in the buds, spray with an arsenical. Spray again in about a week or ten days, just before the blossoms open. This second spraying will serve as the first for canker-worm. Spray a third time just after the blossoms fall. This last spraying, which usually comes in May, will make the second for canker worms and the first for codling moth. The budworm will not appear in numbers demanding treatment, if for any reason the trees were sprayed in winter or spring with the lime-sulfur wash.

The eggs of the SPRING CANKER WORM, *Paleacrita vernata*, hatch some time in April in ordinary seasons and are most readily killed by spraying, if the application is made while they are young. Spray with arsenate of lead or Paris green in Bordeaux mixture, as soon as the leaves are expanded. The second spraying coincides with the first for codling moth and should be given just after the petals fall. Where spraying for codling worm is regularly practiced, it is usually unnecessary to give any attention to canker worms. In case the FALL CANKER WORM, *Alsophila pometaria*, is present, and banding in the fall was neglected, spraying as for the spring canker worm is the right procedure. The eggs of the fall insect hatch coincidentally with those of its spring relative. The larvae of both species are loopers or measuring worms, greenish or brownish in color, with pale or yellowish stripes. When grown, the caterpillars swing to the ground by means of silken threads and, while thus suspended in air, if numerous, are a great annoyance to persons obliged to pass beneath the trees. When disturbed, they lower and raise themselves in similar fashion.

The PISTOL CASE BEARER, *Coleophora malivorella*, and the CIGAR CASE BEARER, *Coleophora fletcherella*, attack the buds as soon as they begin to open and often burrow into them and eat out their entire contents, leaving only empty shells. At this time, the cases are about an eighth of an inch long, and are pistol-shaped and colored like the bark with the first species, more flattened and lighter colored with the second. Later, the caterpillars eat holes into the young fruit and make incisions in the skin of the leaves, through which they protrude their bodies from their cases and work like leaf miners, consuming the pulp between the two skins, leaving only the skeleton of the leaves. They do not leave their cases while feeding, but protrude enough of their bodies through the cut they have made in the epidermis to enable them to mine out an irregular area around the opening. They construct new and larger cases in the latter part of May and continue feeding until the latter part of June when pupation occurs. Treatment is exactly the same as for the bud-worm, both as to time of application and materials to use.

The LIME TREE WINTER MOTH, *Erannis tiliaria* Harris, is quite like the canker-worm moth in habits. The eggs are deposited by the wingless females in October or November and hatch in early spring, or the moths may not issue from the ground and ascend the trees until spring. The larvae are loopers, or measuring worms, somewhat longer than canker-worms. The head of this caterpillar is dull red with a v-shaped mark on the front; the body is yellow above with many longitudinal black lines; the under side is paler. When full grown, about the middle of June, it is about one and one-quarter inch long. Remedies are the same in all respects as for canker worms.

The stem mothers of the APPLE PLANT LICE, or APHIDS, *Aphis fitchii*, *A. pomi* and *A. sorbi*, hatch in late March and during April and early May from shining black eggs laid on the bark and about the buds in the preceding Autumn. The earliest specimens of *A. fitchii* may be expected in late March and early April in southern Ohio, and one or two weeks later in the north half of the State. About the middle of April, the green colonies of young lice may be found clustering on the swelling terminal buds. After passing through several generations, this species migrates during the latter part of May from apple to other host plants and is not again found on apple until fall. *Aphis pomi*, very similar in appearance to *A. fitchii*, appears about two weeks later than the latter species, and is not found on the unopened buds, but, again unlike *A. fitchii*, curls the leaves in characteristic fashion and remains upon apple throughout the season.

A. sorbi, a species containing blackish, reddish, yellowish and brownish representatives among its different forms, appears in late April or a little later; and, during the first half of May, the stem mothers may be found depositing their small brownish young among the green colonies of *A. fitchii*. This species curls the leaves worse than *A. pomi* and like *A. fitchii* is a migrant from apple to other plants, but not until spring is over.

The best treatment for aphids is very thorough spraying with tobacco decoction, kerosene emulsion or whale oil soap. Some of the commercial preparations of tobacco extract are excellent for this purpose. A home-made extract of tobacco is made by boiling one pound of tobacco stems, or dust, for about an hour in one or two gallons of water. When boiling is finished, add water to make two gallons of liquid for each pound of tobacco used; the efficiency of the spray will be increased by adding one or two pounds of whale oil soap to every fifty gallons of decoction. Kerosene emulsion may be used diluted with five parts of water. Whale oil soap, one pound dissolved in four gallons of water, is also quite effective. If leaves are badly curled by the lice, the branches should be bent down and dipped into the liquid.

Some individuals of the WOOLLY PLANT LOUSE, *Schizoneura lanigera*, live through the winter in sheltered positions on the bark as well as on the roots, and both aerial and root forms begin reproduction in the spring. The eggs also hatch at about the same time as those of other apple aphids. This louse is almost wholly confined to the roots and branches. On the roots it produces masses of wart-like swellings and the life of the tree is often endangered. The aerial form is covered with white or bluish-white cottony matter, giving badly infested branches the appearance of being over-run with a luxuriant mold. The treatment recommended for other aphids is efficient against the aerial form. The lime-sulfur wash, when used in winter or in early spring against other insects, will usually render other measures against the aerial form unnecessary. After the leaves appear lime-sulfur can be applied to the trunks and larger limbs by means of a brush and results will be excellent. The underground form may be controlled, if the trees are young, by mixing tobacco dust liberally with the soil in contact with the roots. A top dressing of wood ashes is also advantageous. After trees have become old it is hard to exterminate the lice from the roots. In case young trees to be planted out are infested when they come from the nursey, the roots can be freed from the lice by puddling them in mud impregnated with tobacco. Dig a good sized hole in the ground and in it mix enough loose earth, tobacco dust and water to make a fairly thick slush, or mud, which will readily adhere to the roots. These are immersed in the mud before the trees are planted.

The larva of the LEAF CRUMPLER, *Mineola indigenella*, rouses into activity with the swelling of the buds, cuts loose the silken threads which have anchored its case during the winter, and this is now dragged to suitable feeding grounds among the opening buds and young leaves. The new leaves are drawn toward the mouth of the case, near which they are fastened by silken threads. The worms can now feed in comparative safety without leaving their homes. The deep reddish-brown color possessed by the larva in early spring gives way to a pronounced green as the worm approaches maturity, about the end of May. Also its case has become shaped like a crooked, wavy horn, brownish or blackish in color, closely resembling a piece of bird dung. The interior is lined with silk, and the occupant clings to its house most tenaciously when an attempt is made to remove it. Sometime in late May or early June it transforms within the case to a brown chrysalis. Any ordinary infestation can be controlled by winter treatment. (See Winter Manual p. 17). When present in extreme numbers, the insect should be treated like the bud worm.

Sometimes the expanding buds of apple and other fruit trees are eaten into and destroyed, yet no destructive agent is in evidence to account for the damage. Some parts of the tree fail to leaf out, or the young leaves on an entire branch suddenly disappear. Some of the blossoms are found to have a hole cut through the side of the calyx and the ovary consumed. Such damage is usually indicative of the work of CLIMBING CUTWORMS which feed at night. Several different species work such injury. Banding the trees as for canker worms, with sticky materials, cotton batting or tin collars (See p. 14, Winter Manual) is perhaps the most reliable measure. Poisoned bran mash (See page 78) used in conjunction with banding is very effective. Where early spraying is done for the bud-worms and case-bearers or canker-worms, probably no other measure will be needed.

As soon as the apple leaves begin to unfold, a brownish or yellowish-brown moth with flattened wings which give the insect a bell-shaped outline when at rest, lays its eggs upon them, and the young caterpillars, upon hatching, at once begin to roll the yonng leaves into cylinder form and within this roll they live and feed. When disturbed, they quickly slip out of their retreat and try to escape danger by letting themselves to the ground by means of a silken thread. Besides eating the leaves, they gnaw the skin of the young fruit, leaving scars, which later become brown and rusty. This insect is the OBLIQUE BANDED LEAF ROLLER, *Archips rosaceana* Harris. The larvae work during the entire spring, maturity not being attained until some time in late June or early July. The second and third sprayings made for bud-worms and case-bearers will control this insect.

Another leaf-folder which commences work with the opening of the leaves is *Acleris minuta* Rob., commonly known as the LESSER APPLE LEAF FOLDER. The eggs for the spring brood are laid by a small slate-gray moth and hatch into small green worms, having pale brown or yellowish heads with white markings. The opposite edges of the young leaves are drawn together upwards and fastened with a silken web, thus forming a roofed chamber within which the caterpillar lives. Like all of its family, when alarmed, it deftly lowers itself to the ground by means of a silken thread. It is controlled by the same remedies as the preceding species.

EXPLANATION OF PLATE IV.

a San Jose scale, enlarged.

Negative by Houser.

b Scurfy scale.

Negative by Houser.

c Adult apple tree tent caterpillar, female.

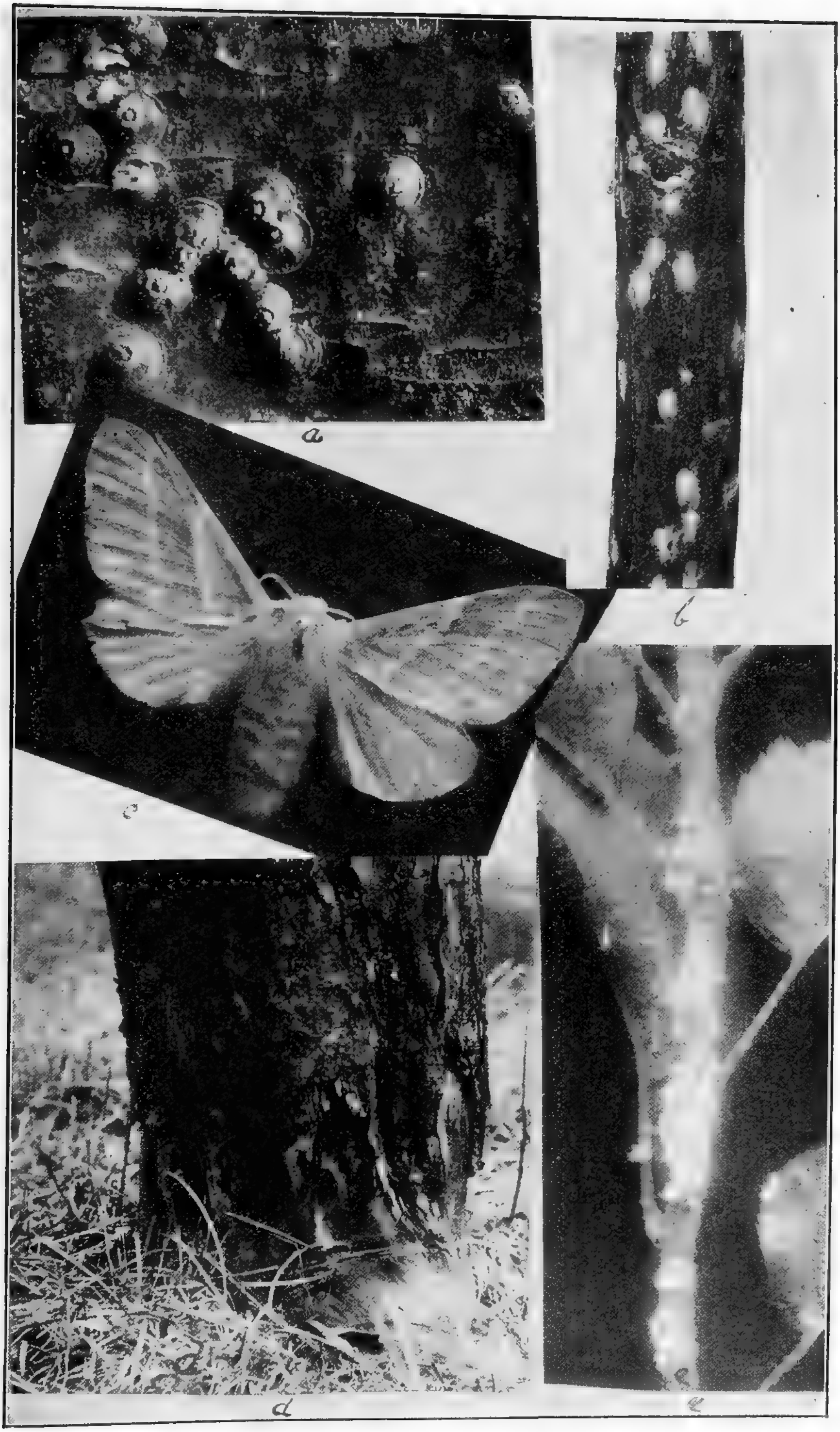
Negative by Houser.

d Injury to twelve year old apple tree by wooly aphis.

Photo by Goodwin.

e Wooly aphis on young limb of an apple.

Negative by Houser.


a
b
c
d
e

MAY.

The eggs of the APPLE TREE TENT CATERPILLAR, *Malacosoma americana*, hatch in April or early May soon after the leaves begin to unfold. As soon as weather conditions are propitious, the caterpillars extend a web across the nearest fork of the twig upon which they were hatched. Later, other layers of silk are added, attachment being made to neighboring twigs and sufficient space left between the layers for the caterpillars to pass. The entrances to the nest are near the extremities or angles of the web and into this shelter the worms retreat for the night, also in stormy weather and when not feeding. Exit to feed usually occurs once in the forenoon and once in the afternoon. The blackish caterpillar has a white stripe down the back and on each side of this central stripe there are a number of short, irregular, longitudinal yellow lines. On the sides are paler lines with spots and streaks of pale blue. The under side of body is pale blackish. In the early morning hours or late in the evening, by means of a ladder, it is possible to gather the web into the gloved hand and crush the whole nest of caterpillars with one squeeze. The same end can be accomplished by tying a rag around a pole and rotating it within the net to collect the web. Holding a lighted torch beneath the nest is also a convenient means of destroying them. Special care must be taken not to scorch the bark and thus kill important branches when using the torch. Orchards that are regularly sprayed with arsenicals for the canker worm, codling moth, etc., are seldom troubled with tent caterpillars.

The eggs of the FOREST TENT CATERPILLAR, *Malacosoma disstria*, also hatch with the opening of the buds. The only web made by this species is a slight one, constructed by the caterpillars while very young, against the side of the trunk or limb on which the nest is located, and this is so inconspicuous that it is usually unnoticed. The caterpillars often march in double column in passing from one point to another. During the evening, and also in the early morning, they are usually found collected in large bunches on the trunks and larger branches of trees. When full grown, they are of a pale bluish color, dotted and pointed all over with black. Instead of the white stripe down the back, possessed by the apple tree tent caterpillar, is a row of ten or eleven oval or diamond shaped white spots. On the sides are some more or less broken pale yellow stripes. When the colony is collected into a bunch, the mass may be burned with a brisk kerosene torch, sprayed with kerosene, or crushed with a club. When collected on a branch to rest or to feed, if the limb is dealt a smart blow with a padded wooden mallet, the worms will suddenly loosen their hold and drop to the ground as if they were shot; by spreading a sheet beneath the tree to catch them as they fall, they may be swept up and emptied into a pail containing water and kerosene. Of limited application is the dislodgment of the worms by means of hydrant water conducted through a hose. When the worms are dislodged without being destroyed, trees liable to their attacks should be protected against their ascent by means of sticky bands, such as are used against the female canker worm moth. Similar bands should be used to protect orchards against threatened invasion from the forest. The remarks regarding the use of arsenicals against the preceding species, apply here.

During the months of March, April and May two or three species of moths (*Xylina* spp.) closely resembling the more common types of cutworm moths are nocturnal frequenters of sugar camps and come readily to sweetened baits. These lay the eggs which hatch a little later, and grow into large, light yellowish or apple green caterpillars, with a narrow cream colored stripe down the middle of their backs, a wide cream colored stripe along each of their sides, and many similarly colored mottlings or spots which sometimes form quite distinct stripes along the bodies above the broad lateral stripes. These worms feed upon the foliage of the apple and of various forest trees. They are known as FRUIT WORMS from their habit of eating into young fruit. The cavity eaten out by one of them often exceeds in bulk the remnant of the fruit which is left. A single caterpillar has been known to destroy six out of eight quinces that were to be found on a tree. Their favorite fruit is the apple, but nearly all of the orchard and small fruits are subject to attack. Before the fruit is set, the caterpillars feed on the leaves and buds, hence, spraying before blossoming time with an arsenical spray, would seem to promise a certain degree of immunity from later damage. After fruiting begins, these worms can hardly be controlled by poisons and the only remedy that has been suggested is to take advantage of their habit of dropping to the ground when they are suddenly jarred, and fight them with the jarring method as if they were curculios. On young trees, the jarring method works very well, but is hardly practicable on old, large trees.

The CODLING MOTH, *Carpocapsa pomonella*, appears about the date the blossoms begin to fall and lays its eggs on the skin of the young fruit, on the leaves, and occasionally on the twigs. These eggs hatch in about a week and 80 percent, or more, of the young worms enter the apples at the blossom end. Each caterpillar remains for several days in the calyx cup, after which it eats its way to the core. It becomes full grown in early summer. A spraying with arsenate of lead, or other similar poison, should be given

EXPLANATION OF PLATE V.

FIG. 1 What will happen next fall if the apples are properly sprayed. Picked harvest of Baldwin tree sprayed three times.

Photo by Goodwin.

FIG. 2 What will happen next fall if the apples are not sprayed. Picked harvest of Baldwin tree, same season in same orchard, not sprayed.

Photo by Goodwin.

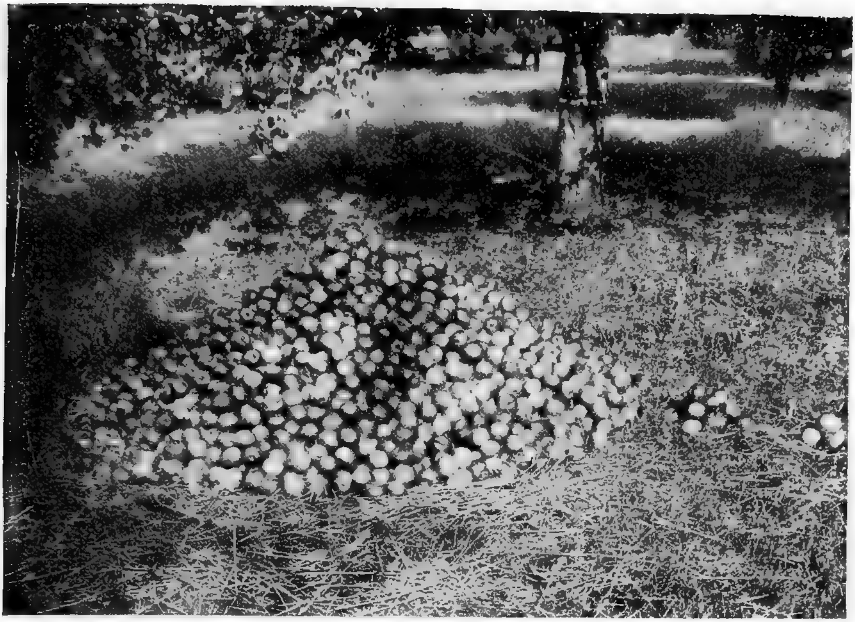


FIG. 1. Sprayed three times.

Picked harvest.

Sonnd, 3152
99.37%

Wormy, 15
.47%

Damaged by
Curculio, 5
.15%

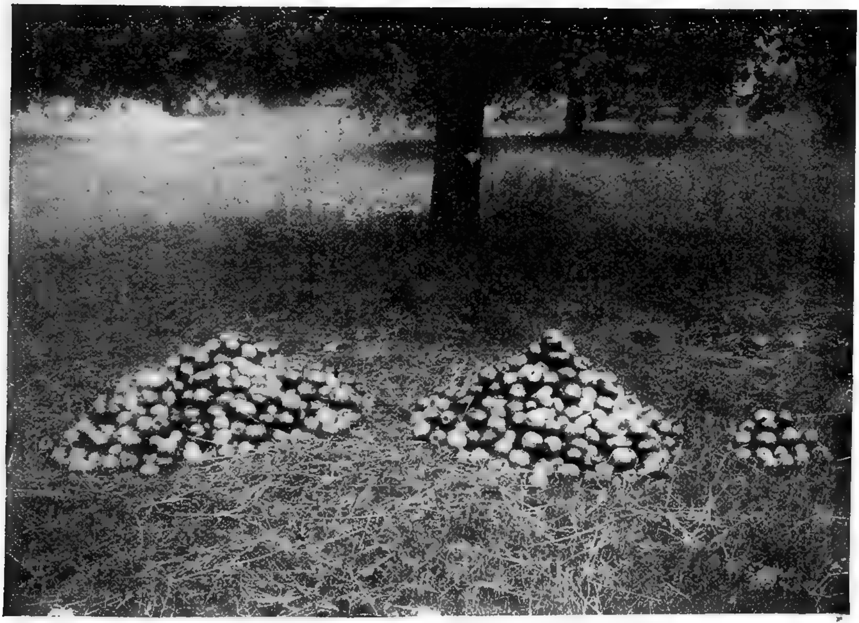


FIG. 2. Not sprayed.

Picked harvest.

Sound, 773
59.83%

Wormy, 461
35.68%

Damaged by
Curculio, 58
6.98%

before the apples have become heavy enough to turn blossom-end downward. Since the mouth of the calyx cup should be turned upward to receive the spray, the application is best made immediately after the petals fall. A second spraying should be made about a week or ten days after the first.

About the middle of May the PLUM CURCULIO, *Conotrachelus nenuphar*, a brown chunky snout-beetle, with black and gray mottlings and four warts on the wing covers, begins to issue from its hibernating quarters and probably feeds sparingly on the leaves until the fruit is set, which is at once attacked. An excavation is made into the pulp, an egg is laid in the cavity, then a crescent-shaped flap is cut around the puncture. The small whitish grub tunnels through the pulp, checking growth, inciting decay, and finally causing the apple to fall. In many orchards this insect does about as much damage as the codling moth. One spraying with an arsenical before blossoming time, a second while the blossoms are falling or as soon as they have fallen, and a third a week or ten days after the second, furnishes the most satisfactory treatment. Since all three of these sprayings have been recommended for other insects, no extra labor is involved in fighting this pest.

About the middle of May appears the APPLE CURCULIO, *Anthonomus quadrigibbus*. This is a snout-beetle like the plum curculio but is slightly smaller. It is dull brown in color and the back is more convex than that of the plum curculio. On the posterior slope of the wing covers are four prominent warts or projections, two on each cover. It commonly infests the thorn apple or wild haws and the native crab-apple. In a puncture made into the pulp with the bill an egg is laid and the outside opening is plugged with a viscid excrement. Later, the puncture shows as a small black spot, located in a depression or hollowed-out basin, covered by stunted growth of the fruit in proximity to the burrows. Remedy, same as for plum curculio.

The ROUND HEADED APPLE TREE BORER, *Saperda candida*, is under discolored bark, usually near the base of the tree. The bark over the burrow is apt to crack in spring, through which a reddish wood-dust sifts to the ground. Open the burrow and destroy the grub with a knife or probe. Where serious injury would be inflicted on the tree by cutting into the burrow, inject carbon bisulphide or chloroform by means of a spring-bottom oil can and close the opening at once with clay, mud or wax, to cofine the fumes. Since the eggs are laid in June, soon after the middle of May give the trunks and larger limbs a heavy coat of whitewash. A little Portland cement added to the whitewash would probably add to its efficiency in preventing the ingress of newly-hatched larvae. The carbolized soap spray recommended in the Winter Manual, as protection against the Fruit-tree Bark Borer, is used by some instead of whitewash. Others take soft or whale oil soap and reduce it to the constituency of a thick paint by adding a strong solution of washing soda in water and a pint of crude carbolic acid to every 8 or 10 gallons of the mixture. This is applied to the entire surface of the bark liable to attack, and, if exposed to several hours of warm sunshine, forms a tenacious coating resistant to rain. The odor repels the females, and such young as hatch perish in trying to penetrate through the greasy mixture.

The FLAT HEADED BORER, *Chrysobothris femorata*, exhibits the same external symptoms of its presence as the round-headed species, but is located higher up the trunk and is sometimes found on the higher branches. Remedies, the same as for the preceding species.

The FRUIT TREE BARK BORER or SHOT HOLE BORER, *Scolytus rugulosus*, becomes especially active with the opening of spring and soon commences to migrate from infested trees to uninfested ones that have, from any cause, become weakened and unhealthy. Badly attacked trees should be cut down and burned, since they cannot recover, and are a standing menace to all others near them. If a tree is not badly attacked, it may be possible to save it, first by removal of the weakening cause which is almost certainly present, and second, by generously fertilizing it. Cover the trunk and larger limbs with whitewash to which some Portland cement and white arsenic or Paris green have been added; or, use instead the carbolized whale oil soap recommended in the Winter Manual, page 19. Since vigorous, healthy trees will not sustain the borers very well, it is important to bring all weakened trees back to a condition of thrift by means of care, fertilizer, and cultivation before they are attacked; also use the whitewash on them to prevent egg-laying and the ingress of young larvae hatching on the bark.

The SCURFY SCALE, *Chionaspis furfurus*, remains in the egg stage until about the middle of May, possibly a week earlier in the southern or a week later in the northern portion of the State, when the purplish young issue from beneath the elongated, grayish or whitish scales. The eggs, from 10 to 75 or more in number, before hatching, are purple, like the young. Treatment should be exactly as for the oyster shell scale, only it should be given one or two weeks earlier.

The OYSTER SHELL SCALE, *Lepidosaphes ulmi*, is in the egg stage until about the last week in May or the first week in June, the whitish eggs from 25 to 100 in number being concealed beneath the brownish scale, which is shaped like an oyster shell. The eggs turn yellowish before hatching. If weather is cool at hatching time, the young remain sheltered beneath the scales until warm weather supervenes. Then they emerge as whitish, crawling specks and settle, preferably near the buds, but, in case of bad infestation, over the young wood, the larger limbs, and finally on the trunk wherever the bark is smooth enough to give them lodgement. As soon as the young are observed crawling over the bark in numbers, which in southern Ohio will probably be during the latter part of May, spray thoroughly with whale oil soap, one pound dissolved in five gallons of water, or with kerosene emulsion, one part of emulsion to nine parts of water. At this period, two sprayings ten days apart should practically control this insect. In central or northern Ohio, the hatching period, or at least a portion of it, is thrown over into June, the summer period.

GENERAL PROGRAM OF TREATMENT FOR THE APPLE. *

When to spray	For what to spray	With what to spray	Remarks
(Special) Late February or in March.	Canker worms.	Band trees with tree tanglefoot, cotton, printer's ink, or wire gauze collars.	Useful in old orchards which have not been regularly sprayed. Gives quicker results than spraying. Not necessary when spraying is regularly practiced.
(Special) Early spring before buds break.	San Jose scale, oystershell scale, scurfy scale.	Lime-sulfur wash or soluble oil.	Not necessary unless scale is present.
(Special) Just as buds are swelling to break.	Bud worms and caseworms.	Arsenate of lead or other arsenical.	Not needed unless the insects are present.
(Special) Just as the green tips of the first leaves burst from the buds.	Bud-worms, case bearers, canker worms, tent caterpillars, leaf rollers, and other leaf-eating insects. Also for scab, canker and leaf spot.	Arsenate of lead or other arsenical in Bordeaux mixture.	Same as above.
* 1 Just before the blossoms open.	For curculio, leaf-eating insects, scab and leaf spot.	Same as above.	Generally considered the most important application for the control of scab.
2 Just after the blossoms fall.	For insects and diseases listed under 1 and codling worm.	Same as above.	The most important application for the control of codling worm and nearly as important as 1 for scab.
3 Ten to fifteen days after 2.	For insects and diseases listed under 2 and bitter rot.	Same as above.	Best results with codling worm will be obtained if this spraying is made about ten days after 2.
(Special) Late May or early June.	Scurfy scale and oyster shell scale.	Kerosene emulsion, whale oil soap or soluble oil.	Spray when young scales are observed crawling in numbers over the bark.
4 About second to last week in July.	For scab, bitter rot, sooty blotch, fly speck, second brood of codling worm and other insects and diseases.	Arsenate of lead or other arsenical in Bordeaux mixture.	Often important against codling worm and fungous diseases. Arsenate of lead is less likely to burn fruit stems and thereby cause falling than other arsenicals.

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*The numbered treatments are necessary and should be given every year at the times indicated. Special treatments are not necessary except for the pests and diseases mentioned

PEAR INSECTS.

MARCH--APRIL.

Reference has already been made in the Winter Manual to the PEAR PYSLLA, *Pyslla pyricola*, and PEAR LEAF BLISTER MITE, *Eriophyes pyri*. If the lime-sulfur wash or kerosene emulsion was not used for these during the winter period, by all means make the application while the buds are swelling and before they have opened, if these pests were present during the preceding summer.

The following pests attacking apple, also feed upon the pear. Reference should be made to the apple section for treatment:

SAN JOSE SCALE, *Aspidiotus perniciosus*. See page 39.
SCURFY SCALE, *Chionaspis furfurus*. See page 51.
OYSTER SHELL SCALE, *Lepidosaphes ulmi*. See page 51.
SPRING CANKER WORM, *Paleacrita vernata*. See pages 39, 40.
EYE SPOTTED BUD MOTH, *Tmetocera ocellana*. See page 39.
PISTOL CASE BEARER, *Coleophora malivorella*. See page 40.
CIGAR CASE BEARER, *Coleophora fletcherella*. See page 40.
APHIDS. See page 41.
LEAF CRUMPLER, *Mineola indigenella*. See page 42.
CLIMBING CUTWORMS. See page 43.
OBLIQUE BANDED LEAF ROLLER, *Archips rosaceana*. See page 43.
LESSER APPLE LEAF FOLDER, *Acleris minuta*. See page 43.

MAY.

APPLE TENT CATERPILLAR, *Malacosoma americana*. See page 46.
CODLING MOTH, *Carpocapsa pomonella*. See page 47.
PLUM CURCULIO, *Conotrachelus nenuphar*. See page 50.

The eggs of the PEAR PSYLLA hatch in May and the young are, at this time, about one-sixteenth of an inch long, yellow in color, afterwards becoming marked with black and red. They are sucking insects and the drain they make upon the vitality of the tree by drawing juices from the leaves is shown early in the season by a drooping of the young growth and considerable dropping both of fruit and foliage. The leaves become covered with a coating of honey dew in which a black sooty mold will flourish later in the season. Flies, wasps and ants swarm about the tree, attracted by the honey dew, and thus give notice of the unhealthful condition that exists. The young insects can be found with sharp eyes or with a magnifying glass, resting in and about the axils of the leaves, immersed in honey dew. While the insects are immature and cannot fly, they may be

EXPLANATION OF PLATE VI.

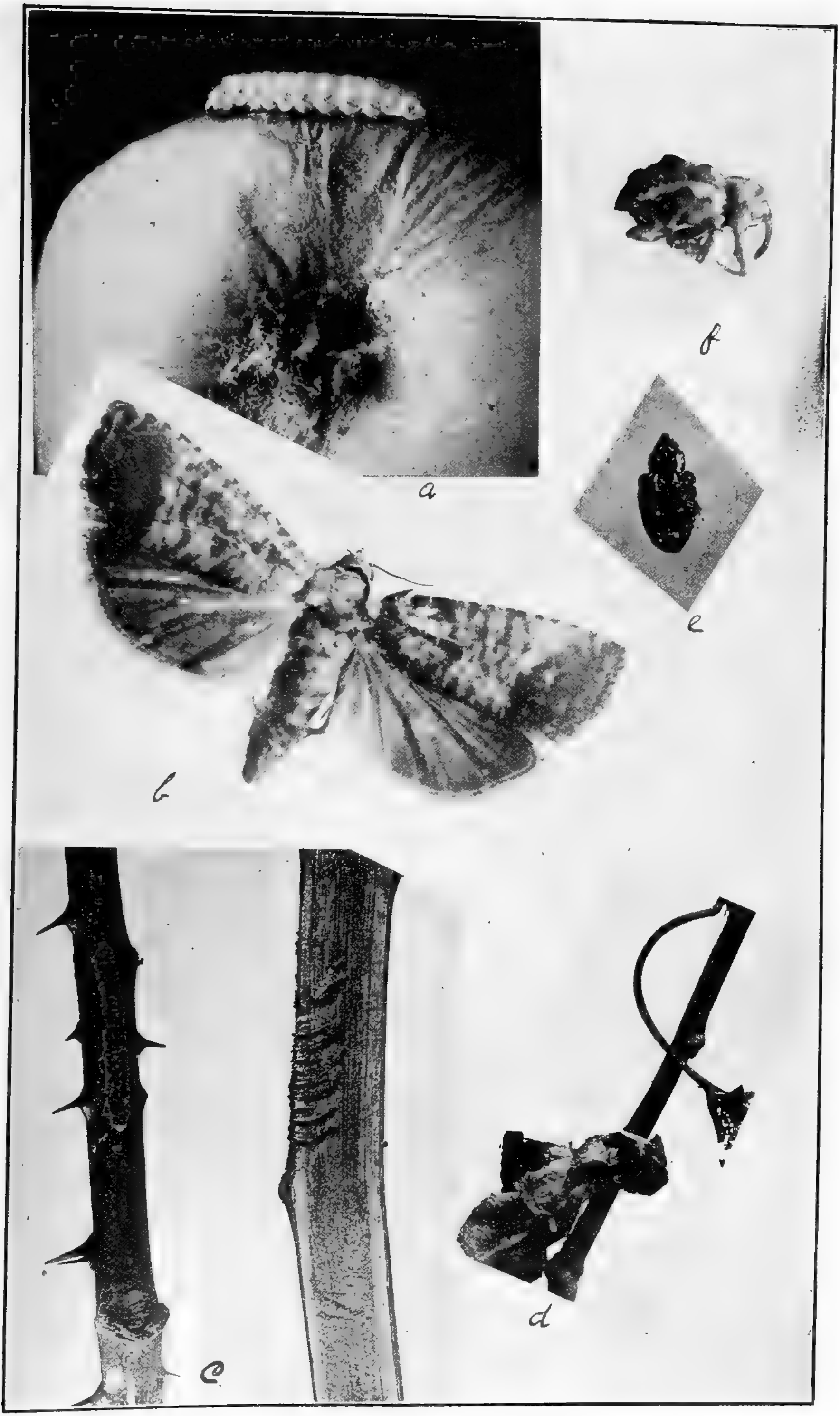
a Codling moth larva on an apple, enlarged.
Negative by Houser.

b Adult codling moth, enlarged.
Photo by Goodwin.

c Tree cricket injury to raspberry canes.
Negative by Houser.

d Apple leaf crumpler, winter home.
Negative by Houser.

e and f Dorsal and side views of a plum curculio.
Photo by Goodwin.


a
f
e
b
c
d

destroyed by spraying thoroughly with kerosene emulsion, one part of emulsion in twenty-five parts of water. Winter treatment is the more satisfactory method, and the grower should endeavor to avoid the necessity of treatment at other times. See Winter Manual.

The PEAR LEAF BLISTER MITE, *Eriophyes pyri*, gives evidence of its presence about the time the young leaves become full grown. Pinkish-thickish patches appear, sometimes extending over the entire leaf. Later in the season these patches become corky and of a dark or black color. Within these corky galls, myriads of microscopic white mites can be found with a magnifying lens, these being the cause of the disfigurements observed. The young fruit, as well as the leaf, is sometimes thus disfigured. The foliage often falls and the fruit crop is sometimes lost. The only season when treatment can be effectually applied is in the winter, but the symptoms of the disease are here recorded in order that the insect's presence may be recognized and, where present, a campaign for the following winter prepared against it.

The PEAR TREE BLISTER BEETLE, *Pomphopaea aenea*, greenish-blue in color, inclining to a metallic luster and somewhat more than half an inch long, attacks the blossoms of the pear, destroying first the corolla and then the pistil and calyx. They will also eat portions of the newly formed fruit. The remedy is to jar the trees in the early morning. The beetles readily drop to sheets spread on the ground for the purpose, and may be destroyed by being put into a pail of water with a kerosene film over it.

The PEAR SLUG, *Eriocampoides limacina*, is the larva of a small, glossy black, four-winged insect about one-fifth of an inch long, that appears on the wing in April and May. The eggs are laid beneath the skin of the leaves of pear, cherry, quince and plum, hatching about two weeks later. The young larvae, slimy snail-like creatures, are not apt to attract attention until late May, at which time the foliage attacked by them appears eaten or skeletonized on the upper side, only the larger veins remaining undevoured. The grown slug is about half an inch long, olive-brown or dirty green in color, having the anterior segments of the body enlarged and the posterior ones tapering down to the tail, the whole body being somewhat shaped into the form of a club. Dry-slaked lime freely dusted upon them by hand, or with a powder gun, will kill them. One part of hellebore, mixed with four parts of dry-slaked lime, is still more effective. Pyrethrum may be substituted for hellebore in the lime mixture, and results will also be good. The arsenites are effective but care should be used in applying them on fruits that are nearly matured and quick in ripening, such as cherries. Even road dust will kill the worms if it is thoroughly applied.

GENERAL PROGRAM OF TREATMENT FOR THE PEAR. *

When to Spray	For what to spray	With what to spray	Remarks
(Special) Early spring before buds open.	San Jose scale, oyster shell scale, scurfy scale, *Psylla*, pear-leaf blister mite, and blight.	Lime-sulfur wash, kerosene emulsion or soluble oil.	Not necessary unless these diseases are present. Lime-sulfur seems to possess considerable value against pear blight. The oils are somewhat more efficacious against *Psylla* and blister mite.
1. Just before blossoms open.	Scab, leafblight, leaf-spot, fire blight and leaf-eating insects.	Arsenate of lead or other arsenicals in Bordeaux mixture.	
2. Just after blossoms fall.	Diseases and insects listed under 1 and codling worm.	Same as above.	Make very thorough spraying to destroy codling worm.
3. Ten to fifteen days after 2.	Same as above.	Same as above.	
(Special) Late May or early June.	Scurfy scale and oyster shell scale.	Kerosene emulsion or whale oil soap.	Spray when young scales are observed to be crawling in numbers over the bark.
(Special) During dormant season and whenever disease appears.	Blight.	Prune out affected twigs and burn. Disinfect knife after each cut by wiping off with a cloth moistened with kerosene. Prune so as to form a low-headed branching top.	A disease that is difficult to combat.

* The program for apple may be followed where apple pests, not here listed, attack the pear.

PLUM INSECTS.

MARCH—APRIL.

The **Plum Gall Mite**, *Eriophyes phloeocaptes*, hibernates during the winter in small sub-spherical galls at the base of the buds. A cluster of galls may completely surround the twig. In early spring the mites leave these galls to form new ones. The newer galls are plump and smooth, but the older ones become dry and wrinkled. Prune out the infested twigs before the buds swell and burn them. Spraying thoroughly with lime-sulfur about the time the buds are swelling will doubtless prove a valuable measure against these mites.

During the winter months and in early spring the larvae of several species of SOFT SCALES, as *Eulecanium nigrofasciatum*, *Eulecanium armeniacum*, *E. persicae*, and *E. prunastri*, are attached to the limbs and twigs, usually on the under side. At this time, they are sometimes quite flat and scale-like, again are more rounded and blister-like, approaching a hemispherical form. They are usually brown, reddish-brown, or blackish in color. As the spring months advance, the scales enlarge and become more rounded in form. Myriads of eggs in the shape of a whitish powder are laid beneath the bodies of the scales in late spring or early summer. The best remedy is kerosene emulsion, one part of emulsion to six parts of water, used as a spray before the trees have awakened from their dormant condition. Or, instead, use whale oil soap, one pound in one gallon of water. The lime-sulfur sprays have not proved very useful against these scales. If early treatment was neglected, spray with whale oil soap, one pound in seven or eight gallons of water, when the the young are observed to be hatching and crawling over the bark. Two treatments about a week apart will generally be advisable.

The following insects attacking apple, also attack plum. Refer to the apple section for information regarding treatment:

SPRING CANKER WORM, *Paleacrita vernata*. See page 39, 40.
FALL CANKER WORM, *Alsophila pometaria*. See page 40.
SAN JOSE SCALE, *Aspidiotus perniciosus*. See page 39.
EYE SPOTTED BUD MOTH, *Tmetocera ocellana*. See page 39.
APHIDS, (*Phorodon humuli*, *Aphis pruni*, etc.) See page 41.
LEAF CRUMPLER, *Mineola indigenella*. See page 42.

Refer to the peach section for treatment for PEACH BORER, *Sanninoidea exitiosa*. See page 63.

MAY.

Refer to apple section for these:

APPLE TREE TENT CATERPILLAR, *Malacosoma americana*. See page 46.
FOREST TENT CATERPILLAR, *Malacosoma disstria*. See page 46.
PLUM CURCULIO, *Conotrachelus nenuphar*. See page 50.

While spraying, as pointed out in the apple section, is the most practicable remedy for CURCULIO in large orchards, the jarring method is preferred by some where the orchards are small. When alarmed by a sudden jar, the curculio will drop from the tree to the ground as if dead and remain motionless, "playing possum," for quite an interval. Spread sheets on the ground beneath the trees and then hit the trunks a sharp blow with a wooden mallet which may be padded with leather to prevent bruising the bark. Several trees may be jarred in this manner before the beetles are collected from the sheets. Put the beetles in a pail of water with a little kerosene floating on top to kill them. Jarring can be successfully done only in the early hours of the morning, usually between 4 a. m. and 8 a. m. Each tree should be jarred two or three times per week during May and June. Sometimes sheets are spread on frames so as to make their transportation easy, and gangs of cheap laborers are employed to carry and arrange them under the trees in advance of the man who carries the hammer on a long handle and is kept busy rapping the trunks.

The PLUM GOUGER, *Coccotorus prunicida*, like the curculio, is a small snout-beetle, a little more than one-fourth of an inch long, with yellowish thorax and legs, and brownish head and wing-covers which are mottled with white and black spots. There are no humps on the wing-covers as with the curculio. The beetle hibernates over winter, and at blossoming time eats a hole through the calyx or green cup-like base of the blossom, thrusts its curved snout through the opening, and devours the ovule or embryo fruit. The eggs are laid in the fruit in holes, externally resembling pin holes, but scooped out and enlarged at the lower end. As soon as the young grub hatches from the egg it burrows its way through the flesh to the young pit, and there subsists on the interior substance of the seed. No external sign of its presence will be left except a small scar from which the gum exudes. As the fruit increases in size, it often develops malformations and becomes knotty in appearance. Spraying is not entirely satisfactory against this pest but is of some help. One spraying to coat the green calyx cups just before the blossoms open is probably the most important application. Subsequent sprayings should be as for curculio. The gouger may also be collected by the jarring process like the curculio, but does not drop so readily, and must be secured promptly after falling, since it quickly takes wing.

Consult the apple section for an account of these:

FLAT HEADED BORER, *Chrysobothris femorata.* See page 51.
FRUIT TREE BARK BORER, *Scolytus rugulosus.* See page 51.
SCURFY SCALE, *Chionaspis furfurus.* See page 51.
OYSTER SHELL SCALE, *Lepidosaphes ulmi.* See page 51.

Refer to pear section:

PEAR SLUG, *Eriocampoides limacina.* See page 56.

EXPLANATION OF PLATE VII.

a Female canker worm.

Negative by Houser.

b Leaf injured by aphids.

Negative by Houser.

c Raspberry Byturus. Adults, enlarged.

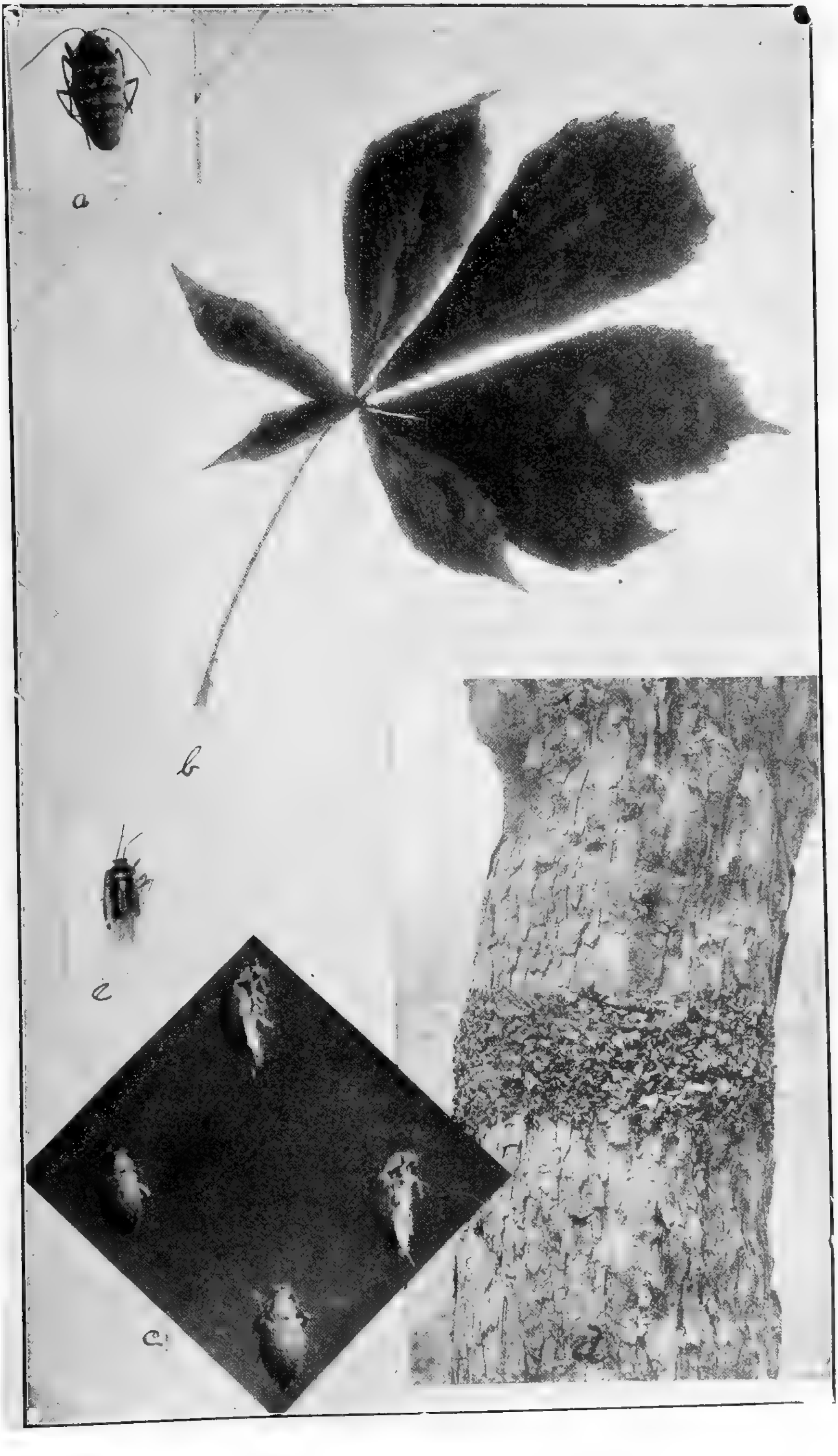
Photo by Goodwin.

d Canker worm moths caught in sticky band.

Negative by Houser.

e Four-lined plant bug. Adult, slightly enlarged.

Negative by Houser.


a
b
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c
d

GENERAL PROGRAM FOR TREATMENT OF PLUM.

When to spray	For what to spray	With what to spray	Remarks
(Special) Before buds open in early spring.	San Jose scale.	Lime-sulfur or soluble oil.	Not necessary unless scale is present.
Same as above.	Soft scales or lecaniums.	Kerosene emulsion, diluted with 7 or 8 parts water.	Apply on sunshiny day.
1. Just before the blossoms open.	Curculio, rots and diseases.	Bordeaux mixture combined with arsenate of lead. On European varieties use standard Bordeaux, on American and Jap. varieties weak Bordeaux.	An important application against rot. Also necessary against curculio.
2. Just after the blossoms fall.	Curculio, brown rot and leaf spot.	Same as above.	The most important application against curculio.
3. Ten to fifteen days after 2.	Same as above.	Same as above.	Necessary against curculio.
4. About the middle of June.	Rot and leaf-spots.	Dilute Bordeaux.	
5. Late July or early August.	Same as above.	Ammoniacal copper carbonate or eau-celeste. Self-boiled lime-sulfur, made with cold water, is worthy of trial.	Change from Bordeaux to these fungicides when the fruit begins to color. Bordeaux used at this time spots the ripening fruit.

PEACH INSECTS.

MARCH—APRIL.

Several species of *Eulecanium* feed on peach. Most of the species already considered in the plum section and perhaps a few others besides, are also recorded on peach. Treatment for these have been given in Plum Section, page 58.

Refer to the apple section for these:

Spring Canker Worm, *Paleacrita vernata*. See pages 39, 40.
Fall Canker Worm, *Alsophila pometaria*. See page 40.
San Jose Scale, *Aspidiotus perniciosus*. See page 39.
Shot Hole Borer, *Scolytus rugulosus*. See page 51.

The Peach Tree Bark Beetle, *Phloeotribus liminaris*, resembles the shot hole borer but is slightly more slender and smaller. The damage resembles that of the shot hole borer. Remedies are the same.

The Walnut Scale, or Gopher Scale as it is known in the southern states, *Aspidiotus juglans-regia*, is often a scourge among peach trees. It looks much like San Jose scale, but is considerably larger, and does not become so black in color as some of the stages of San Jose. The same treatment as for San Jose is said to be effective.

The Peach Borer, *Sanninoidea exitiosa*, is the most universally distributed of peach pests. It may generally be found around the foot of the tree, slightly beneath the surface of the soil, burrowing beneath the bark, thereby causing a copious exudation of gum. Go over the trees as early as convenient in the spring, dig the worms out with a knife and kill them. Some prefer to use scalding water for destroying them in order to prevent mutilation of the bark. An emulsion of chloronaptholeum or of creolin, one part of naptholeum to one hundred and fifty parts of water, would probably give as good results as scalding water.

The Peach Twig Borer, *Anarsia lineatella*, is best destroyed by kerosene emulsion, diluted with seven parts of water, applied in early spring or in winter. The caterpillars spend the winter in minute, silk-lined tunnels in the thickened, spongy bark in the axils of the small twigs. Their presence here is disclosed by little mounds of sawdust or finely ground bark. They begin to migrate to the twigs about the time the buds are swelling in the spring, and in some instances have been destroyed by a spray of lime-sulfur wash during the migrating period. Most of the damage is done in late April or early May, by the larvae tunneling into the new wood, thus killing the terminal growth. No remedy avails at this period.

Peach Aphids may be treated like apple aphids, page 41. The Black Peach Aphis, *Aphis persicae-niger*, feeds on both the foliage and the roots like the woolly plant louse of the apple. All trees received from the nursery should be closely inspected for the pest, since it is a very deceptive and dangerous one. The root form is dark brownish-black, polished and shiny. The form which lives above ground is black, with under side of body dark brown. If there is any possibility that the louse is present, wash the soil from the roots, immerse them in tobacco decoction (Winter Manual p. 13) and, before planting out, puddle the roots in tobacco-impregnated mud as discussed for apple-root louse, page 42.

Consult the apple section for information about these:

Leaf Crumpler, *Mineola indigenella*. See page 42.

Climbing Cutworms, *Mamestra subjuncta*, et al. See page 43.

Oblique Banded Leaf Roller, *Archips rosaceana*. See page 43.

MAY.

The following which attack peach have been treated in the apple section:

Apple Tent Caterpillar, *Malacosoma americana*. See page 46.

Forest Tent Caterpillar, *Malacosoma disstria*. See page 46.

Plum Curculio, *Conotrachelus nenuphar*, page 50, also plum section, page 58.

EXPLANATION OF PLATE VIII.

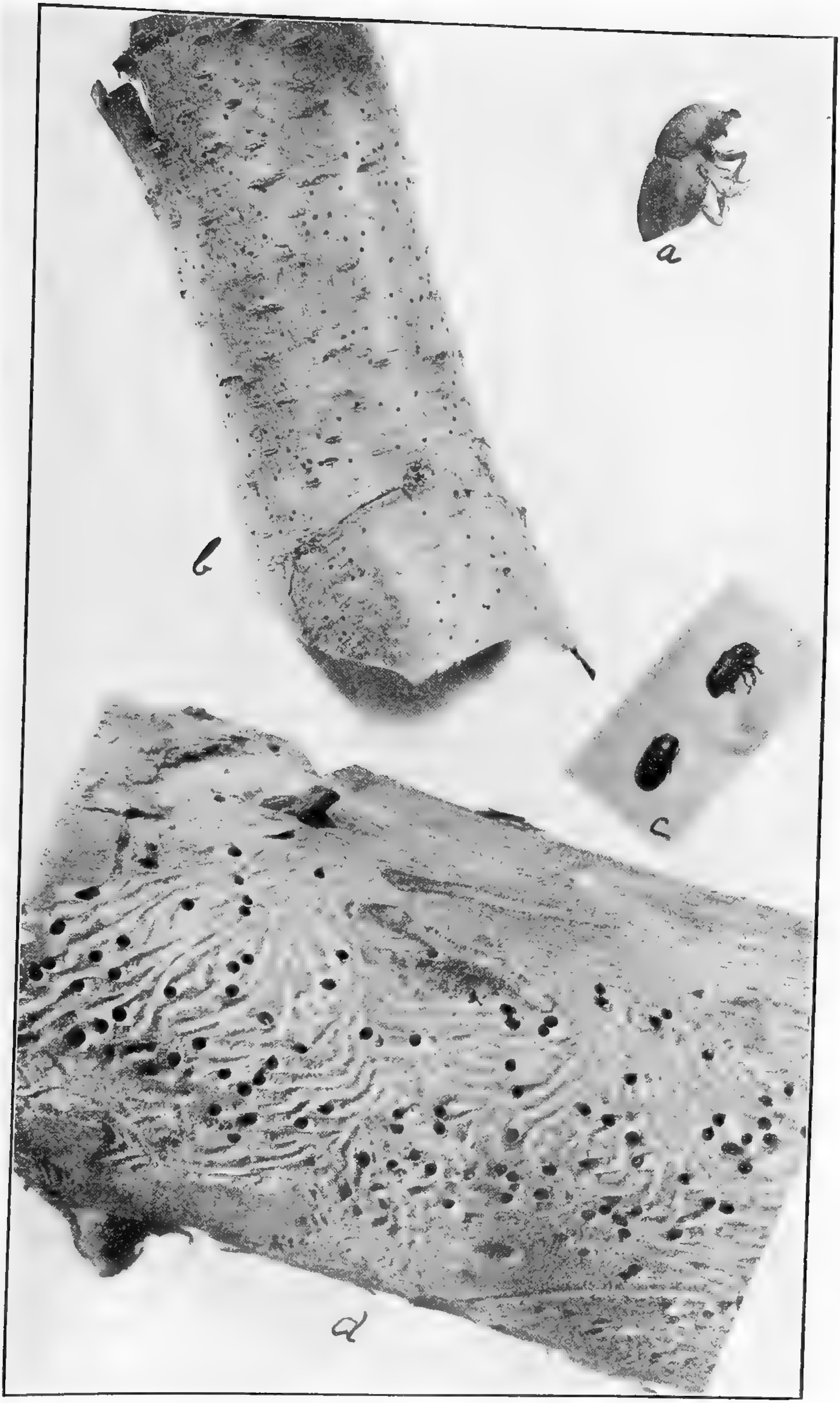
a Shot hole borer, *Scolytus rugulosus*, enlarged.

b Appearance of bark after shot-hole and bark-borers have emerged.

c Peach bark beetle, *Phloeotribus liminaris*, enlarged.

d Shot-hole borer engraving work on peach limb; also holes of pupae, or pupal cells.

Photos by Goodwin.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GENERAL PROGRAM OF TREATMENT FOR THE PEACH.

When to spray	For what to spray	With what to spray	Remarks
(Special) Before buds open in early spring.	San Jose scale and peach leaf-curl.	Lime-sulfur or soluble oil.	Lime-sulfur should be used for leaf-curl whether scale is present or not.
(Special) Before buds open in early spring.	Soft scales or lecaniums.	Kerosene emulsion diluted 6 to 8 times, two applications one week apart, or use soluble oil.	
1. Before the buds open, or better before they swell.	Leaf-curl scab and brown rot.	Lime-sulfur or Bordeaux.	If the lime-sulfur is applied very early in spring the results against leaf-curl are likely to prove best.
2. Just before blossoms open.	Diseases under 1 and curculio.	Bordeaux combined with arsenate of lead.	
3. Just after blossoms fall.	Same as above.	Dilute Bordeaux and arsenate of lead.	Important if curculio is abundant.
(Special) One week after 3.	Curculio.	Arsenate of lead.	Apply if curculio is numerous, also jar trees and collect beetles if they are very destructive.
4. Ten to fifteen days after 3.	Scab and fungous diseases	Self-boiled lime-sulfur made with cold water.	Do not mix arsenicals with this spray.

CHERRY INSECTS.

MARCH.

See apple section for these:

Spring Canker Worm, *Paleacrita vernata.* See page 39, 40.
Fall Canker Worm, *Alsophila pometaria.* See page 40.
San Jose Scale, *Aspidiotus perniciosus.* See page 39.
Scurfy Scale, *Chionaspis furfurus.* See page 51.

See Plum Section for this:

Soft Scales, *Eulecanium* spp. See page 58.

See Peach Section for this:

Walnut Scale, *Aspidiotus juglans-regiae.* See page 62.

APRIL.

See Apple Section for these:

Bud Moth, *Tmetocera ocellana.* See page 39.
Leaf Crumpler, *Mineola indigenella.* See page 42.
Fruit Bark Beetle, *Scolytus rugulosus.* See page 51.
Peach Bark Beetle, *Phloeotribus liminaris.* See page 62.

The Black Cherry Plant Louse, *Myzus cerasi*, attacks the leaves as soon as they expand, congregating on them in great numbers beneath, and attracting swarms of flies and honey-loving insects by a profuse excretion of honey dew. The leaves often become badly crumpled under the attack, and the tree may not recover a wholly healthy appearance during the whole season. Treatment same as for apple aphids, page 41.

See apple section for this:

Oblique Banded Leaf Roller, *Archips rosaceana.* See p. 43.

A large **Flat Headed Borer**, the larva of *Dicerca divaricata*, occasionally attacks the cherry in much the same way as the apple borers attack apple. The same remedies may be used. See pp. 50-51.

MAY.

The **May Beetle**, *Lachnosterna fusca*, and some of its near relatives often attack the foliage in numbers in May. The only feasible remedy is to shake infested trees early in the morning, over sheets spread on the ground beneath to catch the falling beetles. Kill the insects by throwing into a pail of water with kerosene floating on the surface, or use boiling water.

See Apple Section for these:

Apple Tree Tent Caterpillar, *Malacosoma americana.* See page 46.

Forest Tent Caterpillar, *Malacosoma disstria.* See page 46.

Plum Curculio, *Conotrachelus nenuphar.* See page 50.

Scurfy Scale, *Chionaspis furfurus.* See page 51.

See Pear Section for these:

Pear Slug, *Eriocampoides limacina.* See page 56.

Pear Tree Blister Beetle, *Pomphopaea aenea.* See page 56.

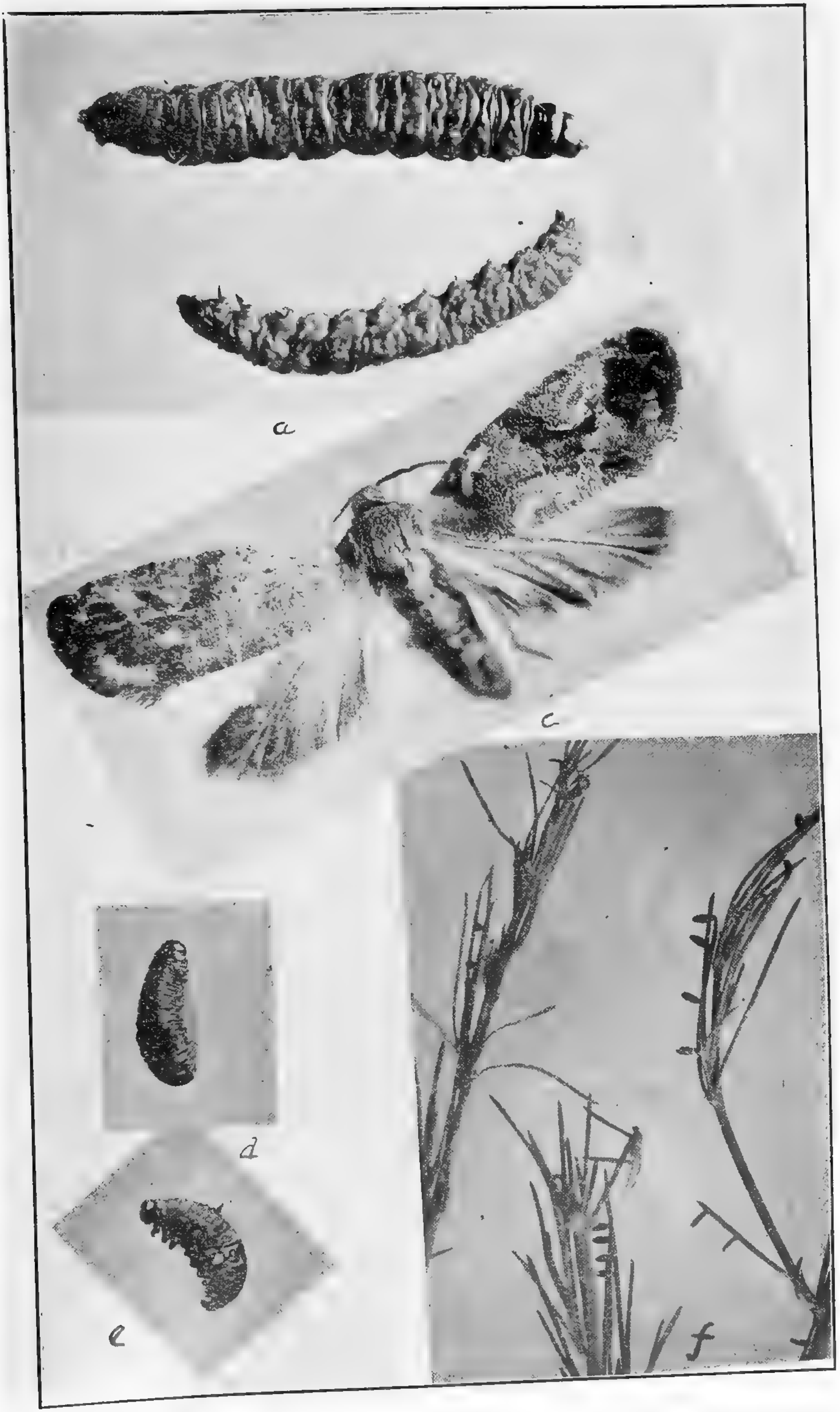
GENERAL PROGRAM OF TREATMENT FOR THE CHERRY.

When to spray.	For what to spray.	With what to spray.	Remarks.
(Special) Early spring before buds open.	San Jose scale and Putnam scale.	Lime-sulfur.	Not necessary unless scale is present. Sour cherries are not seriously attacked by San Jose.
(Special) Early spring before buds open.	Soft scales or lecaniums.	Kerosene emulsion diluted 6 or 8 times, two applications one week apart, or use soluble oil.	
1. Just before blossoms open.	Rot and curculio.	Bordeaux mixture combined with arsenate of lead.	Important against rot.
2. Just after the blossoms fall.	Curculio, rot and leaf-spot.	Dilute Bordeaux combined with arsenate of lead.	The most important application against curculio.
3. Ten to fifteen days later than 2.	Rot and leaf-spot.	Ammoniacal copper carbonate or self-boiled lime-sulfur made with cold water.	These fungicides discolor this early maturing fruit less than Bordeaux mixture.
4. After the fruit is picked.	Leaf-spot.	Bordeaux—use 2-4-50 formula.	
5. From two to three weeks after 4.	Same as above.	Same as above.	

EXPLANATION OF PLATE IX.

a Grapeberry worms, much enlarged.
b Moth of Grapeberry worm, much enlarged.
d and e Asparagus beetle larvae, *Crioceris asparagi.*
f Asparagus beetle eggs.

Photos by Goodwin.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QUINCE INSECTS.

MARCH.

See Apple Section for treatment of these:
San Jose Scale, *Aspidiotus perniciosus.* See page 39.

APRIL.

See Apple Section for these:
Leaf Crumpler, *Mineola indigenella.* See page 42.
Rounded Headed Borer, *Saperda candida.* See page 50.
This insect is very injurious to the quince.

MAY.

See Pear Section for these:
The Pear Tree Blister Beetle, *Pomphopaea aenea.* See p. 56
The Pear Slug, *Eriocampoides limacina.* See page 56.
See Apple Section for these:
Codling Moth, *Carpocapsa pomonella.* See page 47.

GENERAL PROGRAM FOR TREATMENT OF QUINCE.

Same as for Apple—See page 52.

GRAPE PESTS.

MARCH--APRIL.

In the Winter Manual we have emphasized the importance of clean culture. The work of cleaning up the leaves, burning over the borders of the vineyard, and stirring the surface of its soil, should never be deferred until spring if it is possible to do it in the fall or early winter. Spring cleaning up is less effective, in the vineyard, than fall work of the same kind, but it is much better than none. So far as possible, get the leaves out on the borders and burn. It may sometimes be necessary to spray with crude oil over the collected refuse and the thin portions of the border before setting on fire. Cleaning up and burning is very important against the Leaf Hopper or Grape "Thrips," the Grape Flea Beetle, the Grapeberry Worm and the Grape Cane Gallmaker. After pruning, burn all the trimmings. This will destroy the eggs of Tree Crickets and similar insects as well as the larvae and pupae of various insects working within or adhering to the canes.

MAY.

In late May or early June, depending on the latitude and the season, the Grapeberry Moth appears and lays its eggs among the bloom clusters. The Grape Curculio appears about the same time. Since both insects usually appear about the first of June, a fuller mention of each is reserved for the Summer Manual.

GENERAL PROGRAM FOR TREATMENT OF GRAPES.

When to spray	For what to spray	With what to spray	Remarks
(Special) Before buds open in spring.	Anthracnose.	Sulfate of copper solution or Bordeaux.	Not necessary unless disease is present.
(Special) As buds are swelling.	Flea beetle.	Arsenate of lead.	Unnecessary unless the insect is present.
1 Just before the blossoms open.	Mildew, black rot, berry worm and curculio.	Bordeaux combined with arsenate of lead and some form of sticker, such as iron sulfate or soap added.	Very important against berry worm and rot. Very thorough spraying is necessary.
2 Just after the fruit sets.	Same as above.	Same as above.	Same as above.
3 Ten days to two weeks after 2.	For the foregoing and for root worm.	Same as above.	
4 About first week in July. Not later than the 20th.	Same as above.	Same as above.	Probably the most important treatment of all for berry worm. Too late an application leaves spray adhering to fruit at harvest time.
(Special) At intervals of seven to ten days after 4, until fruit is two-thirds grown.	Black rot.	Ammoniacal solution of copper carbonate.	This mixture does not stain fruit like Bordeaux. In ordinary seasons this treatment will be unnecessary if regular sprayings are thoroughly made.

CURRANT AND GOOSEBERRY INSECTS.

MARCH--APRIL.

Nearly all, if not all, of these insects attack both fruits.

San Jose Scale, *Aspidiotus perniciosus*. Spray with lime-sulfur.

Scurfy Scale, *Chionaspis furfurus*. " " " "

Oyster Shell Scale, *Lepidosaphes ulmi*. " " " "

Imported Currant Borer, *Sesia* (*Aegeria*) *tipuliformis*. See Winter Manual.

Native Currant Borer, *Psenocerus supernotatus*. See Winter Manual.

The Currant Span Worm, *Cymatophora ribearia*, appears as a small measuring worm just after the leaves expand. When full grown, it is about one inch long, color whitish, with broad yellow stripes on back and sides, each segment being dotted with some black spots. If disturbed, the caterpillar drops toward the ground by means of a web spun from its mouth. Therefore, the bushes may be jarred and the suspended worms collected and destroyed. Arsenate of lead, applied while the fruit is very young, is safe and effective. For late treatment, dust with fresh pyrethrum mixed with an equal quantity of flour. The adult moth expands over an inch and has pale yellow wings marked with dusky spots. It appears in June or July and fastens its eggs to the stems. The eggs do not hatch until the following spring.

The CURRANT FRUIT WORM, *Eupithecia implicata*, is another span worm, but has ten legs instead of sixteen as is the case with the preceding species. It eats holes into the sides of the fruit. Dust with pyrethrum or spray with strong hellebore.

MAY.

The adult females of the IMPORTED CURRANT WORM, *Pteronus ventricosus*, appear early in May or late in April, and lay their eggs in rows along the midribs on the veins of the leaves. In about ten days the eggs hatch into dull white larvae which later become yellowish-green and dotted over with many black spots. When full grown, the larvae are about three-fourths of an inch long and often defoliate the bushes. The best remedy is to dust the bushes in the morning while the dew is on with white hellebore mixed with four parts, by weight, of flour, or pyrethrum may be used in the same way. Arsenate of lead may be applied as a spray while the fruit is very young, but not much later than the setting period. The adult female is a four-winged sawfly, with a honey-yellow body and black head. The male is black, with yellow spots and yellow legs.

The FOUR LINED PLANT BUG, *Poecilocapsus lineatus*, appears in the nymph form about the middle of May, or a little earlier. The young nymphs are shining vermillion red, marked with black spots on the thorax. They attack the tender leaves near the tips of the twigs. Small brown spots appear at the points where their bills were inserted, and eventually entire leaves and even the shoots may die. The adult insects, which appear in early June, are about one-third of an inch long, orange-yellow in color, with four stripes on the back. The eggs are carried over winter in the tips of the canes, hence, early spring and winter pruning and burning of these will prevent hatching. The young may be destroyed by spraying with kerosene emulsion diluted with five parts of water.

SCURFY SCALE, *Chionaspis furfurus*, young hatch middle of May. See page 51.

OYSTER SHELL SCALE, *Lepidosaphes ulmi*, young hatch middle of May. See page 51.

The GOOSEBERRY FRUIT WORM, *Zophodia grossulariae*, bores into the growing berries, causing them to color prematurely and fall. Several berries may be fastened together as one after another is eaten out by the caterpillar. The moth has an expanse of nearly an inch, the fore wings being pale gray with dark streaks and bands.

The hind wings are pale dusky. The moths appear about the time the bushes are in bloom and lay their eggs on the newly set berries. The pupal stage is passed in a brown, paper-like cocoon, among the leaves on the ground, the pupal period extending from July until the following spring.

Hand-picking the wormy berries is the most reliable remedy but this must be deftly done, since the worms, when disturbed, have the habit of quickly wriggling from the berries and making a rapid descent to the earth by means of a silken thread spun for the occasion. Burning the trash from under the bushes in early spring is also of help in destroying the pupae.

The GOOSEBERRY MIDGE, *Cecidomyia grossulariae*, is a small, yellowish fly, about one-tenth of an inch long, which deposits its eggs beneath the skin of the young fruit. Remedy, hand-picking and destruction of the infested berries.

The CURRANT FLY, *Epochra Canadensis*, is an orange-colored fly, about the size of an ordinary housefly, and has the same general habit as the preceding species. The white maggot, which develops in the fruit, acquires the length of about one-third of an inch when mature. Remedy, handpicking and destruction by burning of the infested berries which color and prematurely fall to the earth.

GENERAL PROGRAM FOR TREATMENT OF CURRANT AND GOOSEBERRY.

When to spray	For what to spray	With what to spray	Remarks
(Special) Before leaves open.	San Jose scale, scurfy scale and oyster-shell scale.	Lime-sulfur.	Not necessary unless scale insects are present.
1 When leaves are unfolding.	Leaf-spot and mildew.	Bordeaux.	Application for mildew on gooseberries may be given before leaves begin to open.
2 Two weeks after 1.	Leaf-spot, mildew, imported currant worm and currant span worm.	Bordeaux combined with arsenate of lead.	Arsenate of lead, if applied just before blooming, adheres long enough to destroy currant worms when they appear.
(Special) Whenever necessary and as often as necessary.	Imported currant worm.	Hellebore 1 ounce in 3 gallons of water, or dust with hellebore 1 part and dry slaked lime 4 parts.	Apply dust while dew is on leaves in the morning.
3 Two weeks after 2.	Leaf-spot and mildew.	Potassium sulfid or sodium sulfid or self-boiled lime-sulfur made with cold water.	Bordeaux, if used at this time, spots the fruit.
4 After fruit is picked.	Leaf-spot.	Bordeaux.	
(Special) Late fall.		Bordeaux.	If leaf-feeding insects have annoyed badly during the season, rake up and burn fallen leaves and trash under the bushes. A straw mulch may then be applied to prevent winter killing.

RASPBERRY AND BLACKBERRY INSECTS.

MARCH.

Raspberry and blackberry canes are sometimes badly infested with a white scale, *Aulacaspis rosae*, commonly known as ROSE SCALE. This insect passes the winter in all stages from egg to adult. Probably no better treatment can be suggested than to cut out all badly infested twigs in spring and burn, and spray the remainder thoroughly with lime-sulfur before the leaves appear. If hatching is vigorous in April, spray with kerosene emulsion diluted with 12 parts of water.

SCURFY SCALE and OYSTER SHELL SCALE, when present, may be sprayed with lime-sulfur in spring before the leaves appear, and in late May with kerosene emulsion if they threaten damage.

See Winter Manual for these:

GOUTY GALL BEETLE, *Agrilus ruficollis*.
SNOWY TREE CRICKETS, *Ecanthus* sp.

APRIL AND MAY.

BUD MOTH, *Tmetocera ocellana*. See page 39.

The RASPBERRY SAWFLY, *Monophadnus rubi*, is a four-winged fly which appears with the unfolding of the leaves. The front part of its body is black, the abdomen dark reddish. The transparent wings are veined with black. The eggs are deposited beneath the skin of the leaf, along the midrib and veins, and hatch into small, whitish slugs which later become of a greenish hue. Spraying with pcisons before the fruit is much grown, or with hellebore later, will be effective; or, dust in early morning with hellebore and flour, or with dry-slaked lime.

The BLACKBERRY CROWN BORER, *Bembecia marginata*, does considerable damage. After growth starts in the spring, some canes may be found to be dead. In some cases, an examination will reveal at the base of such canes, a 16-legged borer, resembling the peach borer. Many of such canes will be found to have been partially girdled just at the base during the preceding fall, and the pith of the same bored out by the caterpillar. The parent moth is a clear winged insect, quite resembling a brightly colored wasp. The body is black, banded and marked with yellow. The eggs are laid in the fall. The most reliable remedy is to cut out all infested canes as soon as they are discovered and burn, taking care not to allow any of the borers to escape from the canes before they are burned.

The PALE BROWN BYTURUS OR AMERICAN RASPBERRY BEETLE, *Byturus unicolor*, appears just as the buds are swelling and eats holes in them, and devours the essential organs of the flowers after they are expanded. This beetle is less than one-sixth of an inch long, yellowish-brown in color, and densely covered with pale yellow hair. Where the blossom has been attacked, but not destroyed, the fruit is one-sided and imperfect. Whole crops are sometimes destroyed in this way. The small whitish worms feed upon the fruit and are found adhering to the fruit at picking time. The beetles work most in the morning and the evening and are not much seen at midday. Handpicking, mornings and evenings, may be satisfactory in small gardens. In large plantings, spraying with arsenate of lead, while the buds are swelling and after the blossoms are open, has been tried with success. The applications may be made with vineyard sprayers, such as are used for grapes.

TARNISHED PLANT BUG, *Lygus pratensis*. See page 76.

GENERAL PROGRAM OF TREATMENT FOR RASPBERRY AND BLACKBERRY.

When to spray	For what to spray	With what to spray	Remarks
(Special) Before leaves open.	Rose scale, San Jose scale and other scales.	Lime-Sulfur.	Cut out and burn the badly injured canes. Spray thoroughly.
(Special) Usually in April.	Rose scale.	Kerosene emulsion.	Use, if hatching is vigorous after the lime-sulfur treatment—an improbable contingency. Dilute emulsion with 12 parts water.
1 Before leaves open.	Anthracnose.	Bordeaux.	
(Special) When buds are swelling.	Pale Brown Byturus.	Arsenate of lead.	Apply very thoroughly.
2 While blossoms are open.	Same as above.	Same as above.	Apply very thoroughly. Bees are likely to be poisoned by this application, but the raspberry crop sometimes cannot be saved without it.
3 When young canes are six inches high.	Anthracnose, leaf-spot.	Weak Bordeaux.	So for as possible, keep spray from leaves on the bearing canes.
4 One week after 3.	Same as above.	Same as above.	Same as above.

STRAWBERRY INSECTS.

MARCH--APRIL--MAY.

In some parts of the country the STRAWBERRY ROOT LOUSE, *Aphis forbesi*, multiplies upon the roots of the strawberry during the growing season until the plants are sapped of their vitality and many of them killed. Dead and unhealthy plants, together with numerous ants among the vines, should incite an immediate examination of the roots. Upon pulling up an infested plant, many of the roots may be found covered with clusters of small, bluish-black lice. Symptoms like the foregoing do not appear until April or May, but the eggs hatch in late March or early April. Whenever there is good reason for supposing the pest to be present, the beds should be burned over in March if this operation was neglected the preceding fall. The very small, shiny black eggs of the louse are laid upon the stems and along the ribs of the green leaves late in fall, usually in late October and November. A mulch of straw kept over the beds in winter will facilitate firing in the spring. In choosing new plants for setting, be sure to use only such plants as come from uninfested beds. If it is impossible to procure clean plants, fumigate the suspicious ones with hydrocyanic acid gas, or dip them in tobacco water, and plant on ground that has not grown strawberries, corn or melons, for a year or more. The reason for avoiding corn and melon land is to dodge the ants that specially care for the different species of aphids that feed on corn, melons and strawberry.

New strawberry plants should not be set on land that has been in grass at any time for two or three years preceding, unless such land is certainly known to be free from the WHITE GRUB.

Various species of CUTWORMS may appear in spring in the beds, or among newly set plants, and do great damage. To destroy these, place poisoned bran bait under boards scattered over the field. See page 78.

The TARNISHED PLANT BUG, *Lygus Pratensis*, attacks the bloom and the forming berries, often causing what is known as the buttoning of strawberries, blackberries, etc. This is a flat, brownish bug, less than one-fourth inch long, marked with yellow and black, giving it the appearance of tarnished brass. Kerosene emulsion made with pyrethro-fishoil soap is probably as effective as any known remedy, but no treatment is very satisfactory.

GENERAL PROGRAM FOR STRAWBERRY TREATMENT.

When to spray	For what to spray	With what to spray	Remarks
1. When leaves are about one-half grown.	Leaf-spot or "rust"	Bordeaux.	Some varieties are not much subject to this disease and may not need spraying. Fruiting beds should be sprayed before blooming. During season of setting, beds may be sprayed almost any time.
2. About two weeks after 1.	Same as above.	Same as above.	For young beds.
3. About two weeks after 2.	Same as above.	Same as above.	For young beds, and is not necessary unless disease is spreading.
(Special) Late May or early June.	Leaf-rollers and "slugs" or sawfly larvae.	Solution of hellebore, 1 oz. in 3 gallons of water.	This is to be prefered before the arsenites on fruit that is from one-half to two-thirds grown. It loses its poisonous properties a day or two after application.
4. After fruit is picked.	For all the above and various other pests.	Cut off vines and other growth close to ground with a mowing machine and burn on a windy day.	A good regular practice except that a drought following the mowing may prevent the development of a crop the following year.
(Special) After mowing and burning.	Same as above.	Bordeaux and arsenate of lead or other arsenical.	Will destroy leaf-rollers and "slugs" that escaped burning.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury.	Remedies to use
March, April, May.	All.	Cutworms.	Stout, soft bodied, hairless, or nearly hairless caterpillars varying from light colors to nearly black. Some striped or spotted with various colors. Conceal themselves in daylight beneath surface of ground, boards, etc.; feed at night.	Cut off plants even with the ground. Some species burrow in stalks of plants, or through the growing heads and roots of vegetables. Others climb plants and even trees to devour the foliage.	Spray grass or weeds with poison on ground in preparation for cultivation several days before plowing; or scatter over the ground before planting a poisoned bran mash made as follows: use one-half pound of sugar or molasses per gallon of water, and use enough of such sweetened water to dampen 50 pounds of bran. Now add one-half pound of Paris green or white arsenic by sprinkling lightly over the surface of the bran, while vigorously stirring so as to mix the poison uniformly through the mass. Vegetables already planted may be protected by a teaspoonful being placed near the base of the plant. This poison keeps effective through a longer period if placed under boards or chips scattered through the garden. Another good poisoned bait is obtained by spraying clover or other succulent vegetation with poison, mowing the same and scattering it in fair sized heaps over the infested ground. Make the piles large enough to prevent the under portion from quickly drying out. Robins, blackbirds and bluebirds destroy many cutworms.
April, May.	All.	Grasshoppers.	Generally speaking, dull colored or greenish jumping insects, at first without wings, later acquiring them.	Devouring plants clean or biting off portions, giving them a ragged, half-eaten appearance.	Use the poisoned bran mash recommended for cutworms whenever the grasshoppers appear. The Criddle mixture, consisting of poisoned horse-droppings, is used very successfully in some localities. The bait is made by thoroughly mixing by weight one part of Paris green with sixty parts of fresh horse droppings. Two pounds of salt dissolved in water is added to each half barrel of the mixture, which is now ready to be scattered around the edge of the garden and also through it by means of a wooden paddle or spade.
April, May.	Corn, beets, potatoes and many others.	White grubs.	Stout bodied, white larvae with hard yellow heads and soft bodies, that live beneath the soil. When removed from the earth, parent forms are the well known stout bodied May beetles, either light brown or dark brown in color.	Cut off roots of grain crops and grasses and cause rough, scabby growth on root crops.	Do not plant vegetable crops on land known to be badly infested. Newly plowed meadows and prairies are most apt to be badly infested. If infested land must be used for garden plot, pasture hogs on it for a few days before planting the crop. They will devour the grubs greedily. If this is impracticable, dilute kerosene emulsion five times with water and pour over the infested ground just before a rain. If rain does not come within a day or two after the application, water generously by means of a hose or by conveying the water in pails. Skunks feed voraciously on the grubs. Barnyard poultry eat them greedily-when exposed by the plow.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of the injury	Remedies to use
April, May.	Potatoes, turnips, corn, beets, cabbage, cauliflower, carrots, onions lettuce, and many others.	Wireworms.	Long, slender, cylindrical worms having hard, shining, smooth bodies of a yellowish color, with three pairs of very small legs, all located very close to the head. Parent forms are the click or snapping beetles.	Eat into grains of seed corn in the ground. Bore channels through underground portions of corn stalks. Bore through tubers of potatoes when planted for seed and while growing and stored. Erode the skins of all kinds of root crops and cut the roots of such crops as develop above ground.	Avoid planting crops specially subject to attack on infested land. If possible, choose for such crops land that has been planted to clover or buckwheat for a year or two preceding, and that was plowed the previous fall. If the worms are known to be present, soak corn in water containing strychnine or arsenic, and sow over the field and harrow in about two weeks before planting the crop. Poisoned slices of potato or bunches of clover or sweetened corn meal mash may be placed under boards scattered about the field for the purpose of attracting the beetles and destroying them.
When insects first appear.	All kinds to some degree.	Aphids or plant lice.	Greenish, blackish or reddish insects of small size, clustering on leaves or stems of plant in great numbers.	Suck the juices from the plants causing them to wither and sometimes to become blotched over or covered with a black sooty mold which grows in the honey dew excreted by the insects. Sometimes the leaves become badly curled.	Spray as often as necessary with soap solution, using one pound of whale oil soap, or other soap, in 5 to 7 gallons of water; or tobacco decoction or kerosene emulsion may be used. Much trouble is saved by treating the first comers as soon as they make their appearance.
When insects appear.	Various.	Flea beetles and leaf beetles.	Very small and generally dark colored beetles that leap like fleas.	Eat leaves full of very small holes and cause them to become blotched with minute white dots in earlier stage of injury.	Spray the greater number of plants with Bordeaux mixture only, and the remainder with arsenate of lead alone. The beetles will congregate on the poisoned plants and those sprayed with Bordeaux alone will be safe to use within two or three weeks after treatment, or sooner. Pyrethrum may be used on plants that are soon to be eaten.
April-Ma	*Asparagus.	Asparagus Beetle, *Crioceris asparagi*.	Slender beetle nearly one-fourth inch long, color blue-black with reddish thorax and yellow spots on wing covers. Larvae are soft and slug-like, color dark gray or olive.	Both adults and larvae attack the tender shoots early in the season and later gnaw the older stalks. Young shoots are made unsightly by great numbers of dark eggs laid in rows of 2 to 6 and set endwise to stalks so as to project in every direction.	Cut all plants down to the ground in early spring, and cut new shoots before eggs hatch. Allow some shoots scattered over the field to grow larger than others and most of the eggs will be deposited on these. When they are well covered with eggs cut and burn and allow other shoots to grow for same purpose. The larvae may be killed by dusting with fresh air-slaked lime while dew is on in the morning. Spray with arsenate of lead later in the season when cutting period is over. Chickens and ducks will devour many if given the run of the garden.

Alphabetical arrangement of crops begins here.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
April-May.	* Asparagus.	Twelve spotted asparagus beetle.	A trifle larger and stouter than the common species, uniformly reddish in color, with 12 black spots on the wing covers. Eggs are attached by their sides instead of ends, usually on old plants instead of young shoots if such are available.	Hibernated beetles feed on shoots in spring. Later beetles and larvae prefer the berries. Larvae seem to feed almost exclusively on the berries.	Follow same method as for the preceding where possible. Older plants may be used for traps. Owing to habit of larvae in entering berries, dusting with lime is of no avail. Spraying with poison will destroy many of the beetles.
At planting.	Beans.	Common bean weevil, *Bruchus obtectus*.	Small, chunky beetle, rather square across the back end of the body and diminishing in width toward the front to form a wedge shape. Color, brownish gray or olive.	Eat out interior of seed and make round holes through outside.	Fumigate with bisulfide of carbon before planting so no beetles will be carried to the field. If properly fumigated in fall and winter this will be unnecessary. Throw infested seed lightly into water. All floating beans should be destroyed as they are too badly injured to grow well.
Before planting and when injury becomes apparent after plants are up.	Beans.	Seed corn maggot, *Pegomya fusciceps*.	Small, footless larvae, narrowed at front end, enlarged posteriorly. Adult resembles small house fly.	Larvae scrapes and devours seeds, sprouts and stems under ground, causing them to wither and die.	Hand-picking by lifting plants from ground, removing maggots and resetting. With a force pump apply hellebore-2 oz. of powder to the gallon of water-about the roots of plants as soon as infestation is apparent. Mineral fertilizers are useful to prevent egg laying and to stimulate plants to outgrow injury; use as top dressing before planting, and afterwards a short distance from stems on surface just before or after rain. Too much fertilizer to stems or roots is dangerous to plants.
See p. 78.	Beans.	Cutworms.			
See p. 79.	Beans.	Flea-beetles.			
Before planting and when insects appear.	Beets and nearly all garden crops.	Plant-bugs, *Lygus pratensis*, etc.	Flattened, sucking bug, nearly one-fourth inch long when full grown, brownish in color, marked with yellow and black. Hibernates under grass and rubbish.	Sucks juices, causing plants to wither and often carries disease from sick plants to others.	Burn all rubbish in spring if this was omitted in fall. Spray young bugs with kerosene emulsion diluted with 12 to 15 parts of water. Collect old bugs by sweeping plants with cheese cloth or muslin net when insects are stupid in early morning or when it is cold.

* Crops are arranged in alphabetical order from this point.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insects	Character of injury	Remedies to use
See p. 79.	Beets.	Flea-beetles.			
See p. 78.	Beets.	Cutworms.			
See p. 78.	Beets.	Grasshoppers.			
At planting time and as needed afterwards.	Cabbage, radish, turnip, cauliflower, cruciferous crops.	Cabbage maggot, *Pegomya brassicae.*	Adult fly resembles the housefly but is small and rests on the ground in gardens, flying up when disturbed. Larva is a whitish maggot, one-third inch long when mature.	Several maggots may work on the same root. They scrape away the outside tissue and cause rot to start and also bore tunnels through roots. Radishes are often rendered unmarketable from being burrowed.	Put a teaspoonful or more of tobacco dust around the stem of each plant at setting time, and renew the application once per week for three weeks after planting. Removing plants from ground, cleaning by hand and resetting is sometimes practiced with good results. Carbolic emulsion made as follows is often used: stock solution, 1 lb. hard soap dissolved in one gallon of boiling water; add one pint crude carbolic acid and emulsify at once by pumping the liquid back into itself with a force pump. Dilute with 30 parts of water, and pour one-half pint around each plant. This saturates the soil and destroys the maggot.
Begin soon after setting and continue through season.	Cabbage, cauliflower and other cruciferous crops.	Imported cabbage worm, *Pontia rapae.*	Butterfly white, expanse 2 inches, fore wing tipped with black, pair black spots on each fore wing, a black spot on each hind wing; males, one spot on each fore wing. Caterpillars, velvet green, over one inch long when mature.	Eats leaves full of holes, sometimes delaying growth and heading for several weeks.	When plants are young, spray with arsenate of lead or Paris green. If desired, combine poison with Bordeaux and put in one pound of dissolved soap with each ten gallons of spray to make it stick. After heading commences, do not use poison, but mix one part by measure of pyrethrum with 4 parts of flour and dust over the plants when the dew is on in the morning. About one dusting should be given each week.
Soon after plants are set and as often as necessary.	Cabbage, cauliflower and cruciferous crops; also celery, lettuce, beets and other garden crops.	Common cabbage looper, *Autographa brassicae.*	The larva is a green worm, lined with white, over one to one and one-quarter inch long when grown. Has the looping habit like the span worm.	Same as with preceding species.	Same as for Imported Cabbage Worm. Both species may be controlled with hot water, the temperature of which should be from 150° to 160° when it reaches the worms by spraying. Spraying with salt water is also useful.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
Soon after plants are set and as often as necessary.	Cabbage and cruciferous crops.	Diamond-back moth, *Plutella macullipenis.*	The larva is a very small green worm. The moth is about one-third inch long and folds its wings roof-like over its body. A white line borders the inside of each fore-wing and these coalesce to form a single white stripe down the back with diamond-shaped expansions at intervals when the wings are folded.	Larvae usually feed on lower surface of leaves and not until quite numerous do they eat holes clear through.	Same as for other cabbage worms.
See p. 78.		Cutworms.			
Soon as insects appear which may be as soon as plants are set.	Cabbage, cauliflower and most garden crops.	Flea beetles, *Phyllotreta vittata, Phyllotreta pusilla,* etc.	Minute beetles that jump like fleas, sometimes called "garden fleas."	Adult beetles eat epidermis through in spots, making the leaves appear blotched over with minute spots. Damage may proceed further and considerable portions of the tissue be eaten.	Spray with arsenate of lead in Bordeaux mixture. Bordeaux alone has considerable repelling power against these insects. Spray at once as soon as the beetles appear. See page 79.
April and May before regular crop is planted.	Cabbage, cauliflower and other cruciferous crops.	Harlequin cabbage bug.	One of the stink bugs, often called the "calico back." Darker portions of body are shining black or dark blue. The spots are yellow or red.	Sucks sap from leaves causing them to wilt. May destroy an entire field of plants	Plant an early trap crop of mustard, radish, rape or other cruciferous plants and when bugs are collected on the traps spray with pure kerosene, or kerosene emulsion diluted with 4 parts water; or collect insects by sweeping with a hand net and burn. If early insects are destroyed later ones will not follow.
	Cauliflower.		See Cabbage insects, pp. 81-82.		

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
Soon as plants are through ground.	Cucumbers, squashes and curcurbits of all kinds.	Striped cucumber beetle, *Diabrotica vittata*.	Small beetle, 1-5 in. long, straw-yellow in color with two black stripes on each wing cover. The inner stripes of each wing coalesce when the wings are closed, making one stripe, thus giving the appearance of three black stripes on the back when the insect is at rest. The larvae are long, slender, whitish worms, somewhat resembling wireworms but not so tough skinned.	The adult beetles collect on the stems just at the surface of the ground and gnaw the epidermis; also may eat holes in leaves. The larvae burrow through the stems and roots, causing the plants to wilt and die, especially in dry weather.	Put a large tablespoonful of tobacco dust around each stem as soon as the plant appears and likewise sprinkle the dust over the leaves when the dew is on in the morning. Repeat the tobacco applications once per week and always after a rain. The vines should be kept well covered for several weeks after the plants start. A mixture of one pound of flowers of sulfur to three pounds of dry-slaked lime may also be used for dusting, but should not be put about the roots like tobacco dust. Spraying with Bordeaux mixture to which arsenate of lead has been added is of considerable value. Early varieties may be started under glass and transplanted to the field, attaining considerable strength before the beetles appear. Successive plantings on the same land are successfully used by some. The newer plants are attacked and the older ones unmolested.
Soon as plants are through the ground.	Cucumbers and other cucurbits, corn, etc.	Twelve-spotted cucumber beetle, *Diabrotica 12-punctata*.	Greenish-yellow beetle, ¼ inch long, with six black spots on each wing cover.	Similar to that of preceding species.	Same as for striped cucumber beetle.
Soon as bugs appear.	Cucumber, cucurbits and many others.	Melon louse, *Aphis gossypi*.	Blackish-green plant louse, both winged and wingless forms occurring.	Insert their beaks into leaves and suck sap.	Keep a lookout on undersides of all leaves for first comers and destroy by burning the affected leaves. If the insects have appeared, spray with fishoil-soap kerosene emulsion to which pyrethrum has been added. Have an adjustable nozzle or a bent extension rod that enables the operator to throw the spray upwards against the under sides of the leaves. Dilute emulsion with 12 to 15 parts of water. Dusting under sides of leaves with pyrethrum is of value when only needed on a small scale.
See p. 78.	Same as above.	Cutworms.			
When insects appear.	Lettuce.	Aphis or green fly.	Greenish lice.	Suck juice from plant in greenhouses.	Use abundance of tobacco dust about roots and sprinkle over leaves. Fumigate with nicotine or tobacco. Tobacco dust worked into the soil.

INSECTS OF THE VEGETABLE GARDEN.

Date of treatment	Crops subject to attack	Name of insect	Description of insect	Character or injury	Remedies to use
When insects appear.	Lettuce.	Lettuce earth-louse, *Rhizobius lactucae*.	Dull white louse with dusky legs and antennae.	Suck juices from root.	Drench roots with decoction of tobacco made by boiling 1 lb. of cheap or refuse tobacco for 1 hour in water. Dilute to 1 gallon of liquid for each pound of tobacco used.
"	"	Cutworms see p. 78.			
	"	Cabbage looper, *Autographa brassicae*. See p. 81.			
"	Melon.	Melon louse, *Aphis gossypi*. See p. 83.			Same as when on cucumber.
"	"	Striped cucumber beetle *Diabrotica vittata*. see p. 83			"
	"	Twelve spotted cucumber beetle, *Diabrotica 12-punctata* See p. 83.			"
"	"	Cutworms See p. 78.			
"		Flea-beetles. See p. 79.			

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
Egg laying begins in May.	Onion.	Imported onion maggot.	Adult insect resembles small housefly. Small white maggot resembles the cabbage maggot.	Maggots cut into bulbs, causing them to decay. Eggs are laid on young plants early in spring; several generations per season.	Read section on cabbage maggot, p. 81. Good results have been obtained in some cases by taking a cupful of sand, soaking the same in kerosene then mixing with a pailful of dry sand and scattering it along the rows at the bases of the plants. This repels adults, prevents egg-laying and kills any young larvae that may try to penetrate through to the plants. Lift out and destroy all badly infested plants as soon as they begin to wilt. Use commercial fertilizer freely to stimulate plants to outgrow injury.
Soon after young onions start into growth.	Onion, cives.	Black onion fly, *Tritoxa flexa.*	Adult is two-winged fly about ⅓ inch long, body black, three oblique white bars on each wing. Maggot white; larger than that of the Imported Onion Fly	Feeds on onions in field and in storehouse.	Same as for Imported Onion Fly. Infested onions in store should be fumigated with bisulphide of carbon for 48 hours, one pound of liquid to each 100 cubic feet of space to be treated.
"	Onions and supposed also to attack various field and garden crops.	Barred-wing onion maggot, *Chaetopsis aenea.*	Adult is metalic bluish-green, two-winged fly, about ¼ inch long, wings transversely crossed by three smoky bands, the outer ones coalescing at each end.	"	As for the preceding species. The usual period of severe attack is later in the season than spring, but young plants being transfered from hothouse to field should be examined and, if infested, even in slight degree, should be dipped into strong tobacco decoction or kerosene emulsion diluted with ten parts of water.
At planting time and afterwards whenever necessary.	Onions and nearly all garden vegetables.	Onion thrips, *Thrips tabaci.*	Minute, active, yellowish insects not over 1-20 inch in length. The four wings are very slender and fringed with long delicate hairs. Have the habit of elevating their abdomens and jumping like fleas.	Parent insects usually found on lower sides of leaves while both old and young are found under leaf-sheaths of plants. They scrape the tissue in minute spots, giving a whitish, blighted appearance to plants, especially after they begin to wilt for want of juice under prolonged attack. The leaves and tops decay in wet weather and rotting may extend to the bulbs.	All grasses, weeds, etc., in proximity to onion fields should be burned over in spring or plowed under to destroy the hibernating insects. Spray with kerosene emulsion or tobacco water whenever necessary. Drenching plants with a hose is useful.

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops sunject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
Do not usually appear until late May or June. Read "Remedies" in 6th column at planting time.	Peas.	Pea aphis or louse, *Nectarophora destructor.*	A pea-green louse less than one-fourth inch long in case of females.	The lice gather in clusters about the terminals, and as they multiply, attack both leaves and stems, sapping the vines to death.	Spray with kerosene emulsion diluted with 12 parts of water. Wet both upper and under surfaces of leaves thoroughly. Early plantings of early varieties are seldom attacked. Rotate crops and in an infested district do not plant peas near fields which were planted to legumes the preceding year.
At planting time.	Peas.	Pea weevil, *Bruchus pisorum.*	Stout, chunky beetle about one-fifth inch long, dark brown in color and having black and white markings.	A minute dot is the only evidence of infestation in green peas. The adults issue from the dried peas through round holes.	If seed is kept over for two years all weevils will be dead, since they do not breed in dried peas after the manner of the bean weevil. Do not allow the issued weevils to escape to the fields to perpetuate their injuries. If it is desired to plant seed produced the preceding year, fumigate with bisulfide of carbon as directed for the bean weevil.
		Seed corn maggots, *Pegomya fusciceps.* See page 80.			
As soon as vines are 6 in. high or earlier.	Potato.	Potato beetle, *Leptinotarsa 10-lineata.*	Chunky beetle, approaching hemispherical form. Light yellow in color, with ten black stripes down the back. Length, one-half inch. Larvae are soft round slugs ornamented with black dots.	Both adults and larvae are provided with biting mouth parts and devour the foliage, sometimes stripping off all leaves.	Spray with arsenate of lead or Paris green. Combine these with Bordeaux mixture and spray at same time for blight. Dusting with Paris green mixed with 20 parts by measure of lime dust is practiced by some. Hand-picking in early spring is very satisfactory on small areas. Throw the captured beetles into pails containing water and a little kerosene.
	Potatoes.	Flea beetles, *Epitrix cucumeris*, et al. See page 79.			

Date of treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
Whenever the insects appear.	Potatoes.	Aphids or lice, various spp.	Small greenish lice.	Suck juices from leaves, causing wilting.	Spray with kerosene emulsion.
Soon as plants are up.	Radish.	Cabbage maggot or radish maggot.	See page 81.	Erode skins and burrow through roots.	Same as for cabbage. See page 81.
	Squash.	Cucumber beetle, *Diabrotica vittata.* See page 83.			
At planting time.	Squash and all cucurbits.	Squash bug, *Anasa tristis.*	One of the "stink bugs" about ¾ inch long, dull blackish brown above, mottled yellowish beneath.	Suck the sap from the stems and leaves, causing wilting. May transmit vegetable diseases from plant to plant.	Plant some hills of squash earlier than main crop to serve for traps. Traps of squash or pumpkin will partially protect other cucurbits. Place shingles and pieces of board about the garden and look beneath them each morning in the early season for the bugs which should be destroyed.
Soon as weather is warm and frosts are over so seed can be planted.	Pumpkins, etc.	Squash-vine borer, *Melittia ceto.*	Moth has expanse of 1¼ inches, and is reddish brown marked with black or bronze, fore wings olive brown with metallic reflections, hind wings clear. Larva soft, whitish and grub-like. Nearly one inch long when full grown.	Larvae bore tunnels in stems and descend to root, being usually found near the level of the soil, sometimes a little above, again a little below. It causes wilting of vines as if attacked by bacterial disease. Yellowish saw-dust-like excrement is found on ground under burrows.	Plant summer squashes for traps as early as possible on ground which is intended for main and later crop. Let these grow between the rows of the main crop until they are well stocked with borers, then pull up and burn. Other remedies belong to Summer Manual.
	Sweet Corn.	Same insects that affect field corn. See section on Corn Insects, p. 34.			

INSECTS OF THE VEGETABLE GARDEN.

Date for treatment	Crops subject to attack	Name of insect	Description of insect	Character of injury	Remedies to use
	Sweet potato.	Flea beetles, various spp. See p 79.			
When damage appears.	"	Tortoise beetles, *Cassida* spp.	Small beetles more or less resembling lady bugs or, even more strikingly, miniature tortoises. They often resemble burnished gold in color.	Eat numerous round holes in the leaves.	Spray with arsenate of lead if injury threatens to become serious.
	"	Cutworms, See p. 78.			
	Tomato.	Cutworms, See p. 78.			

APPENDIX.

RECORDS OF BIRD MIGRATION.

The following records of bird migration were made by Mr. Scott Harry who has, for several years, been employed by the Horticultural Department of the Ohio Experiment Station, and by Mr. Albert I. Good, formerly a student at the University of Wooster, and also at one time employed as an entomological collector by the Experiment Station. Both gentlemen are well qualified to make such records and their work may be relied on as being accurate. The records were all taken at Wooster. The notes are largely based upon Dawson's Birds of Ohio. Such an entry as 3-11 in the date column for any year means March 11, etc.

	Date of record—Harry.								Date of record—Good.								
	1901	1902	1903	1904	1905	1906	1907	1908	1899	1900	1901	1902	1903	1904	1905	1906	
Blackbird, Red-shouldered	3-11	2-28	1-19	3-9		3-28	3-2	3-11	3-10	3-7	3-10	2-27	3-5	3-16	3-11	3-9	Summer resident in ponds and marshes.
Bluebird	1-1	1-20	1-?	1-?	2-3	1-21	2-28	2-12	3-2	2-10	2-7	2-8	2-9	3-1		2-22	Summer resident. Winter resident in southern Ohio.
Bobolink	5-2	4-29	5-1	4-24	4-21	4-?	4-28	4-23	4-29	4-28	5-6	4-30	4-29	4-28	4-28	4-25	Summer resident in northern Ohio. Migrant only in southern Ohio.
Bunting, Black-throated	5-31																Not plentiful. Rare or wanting in northern and eastern Ohio.
Bunting, Indigo	5-12	5-11	5-15	5-8	5-7	5-6	5-13	5-14	5-11	5-14	5-10	5-3	5-12	5-7	5-5	5-4	Summer resident. Breeds throughout the state.
Catbird	5-4	4-27	4-30	5-1	4 29	4-28	4-29	4-24	5-2	5-1	5-10	5-1	5-2	5-5	5-1	4-27	Summer resident. Breeds in bushy tangles everywhere.
Chat, Yellow-breasted.	5-30	5-1	5-8	5 8	5-7	4-29	5-8				5-11	2-6	5-8	5-5	5-5	5-4	Abundant in southern Ohio; less so in north. Nests in briar thickets.
Cowbird	3-16	3-12	3-13	3-26		4-2	3-17	3-13	4-12	4-12	3-23	3-27	3-18	3-21	3-15	3-29	Common summer resident. Appropriates nests of other birds.
Creeper, Brown	2-13	2-6	1-9	4-4	3-25	3-16	1-11	2-28			4-6	4-4	3-23	4-4	3-22	4-12	Winter resident in southern Ohio. Casual winter visitor in northern section.
Crow									2-20	1-20	2-15	2-11	2-10	2-9		1-14	Common winter and summer. Partially retires from northern half of state in winter.
Cuckoo, Black-billed	5-24		5-15												5-5	5-14	Not abundant. Summer resident in northern Ohio; less common southerly.
Cuckoo, Yellow-billed	5-14	5-15	5-9	5-28	5-14	5-14	5-15	5-16	5-13	5-19	5-22	5-12	5-19	5-27	5-25	5-13	Common summer resident. Not so abundant northerly.
Dove, Mourning									2-20	3-24	2-3	3-10	3-9	3-20	3-17	4-1	Common summer resident. Winter resident in southerly part of state.
Finch, Purple	3-27						5-8							4-30		4-21	Spring and fall migrant. Occurs casually in winter.
Flicker									2-17	3-14	2-15	1-6	1-1	3-7	3-4	2-20	Not uncommon. Sparingly resident, most commonly in southern Ohio.
Flycatcher, Acadian	6-9	5-17	5-15	5-8	5-21	7-9											Abundant summer resident.
Flycatcher, Crested	5-10	4-27	5-4	5-3	5-7	5-13	5-18				5-9	4-28	5-7	5-5	5-5	4-30	Common summer resident all over state.
Flycatcher, Least	5-15	5-13	5-8	5-12	5-4	5-13	5-12			5-9	5-6	5-7	5-2	5-5	5-1	5-11	Common migrant. Occasionally summer resident.

RECORDS OF BIRD MIGRATION. Continued.

	Date of record—Harry.								Date of record—Good.								
	1901	1902	1903	1904	1905	1906	1907	1908	1899	1900	1901	1902	1903	1904	1905	1906	
Flycatcher, Traill's	7-13	6-15	5-9				6-10	5-15			5-3	5-6	6-3	5-21	6-5	5-18	Summer resident. Nests in willows and alders of swamps.
Gnatcatcher, Blue grey												5-1	4-18	4-23	4-15	4-14	Abundant summer resident; less common in northern portion.
Goldfinch	3-25	1-10	1-16	1-14	1-9	2-10	2-4	2-12									Summer resident; partial winter resident.
Grackle, Bronzed	2-15	3-1	3-9	1-22		3-5	3-11	3-6	3-1	3-8	2-15	3-3	3-7	3-1	3-4	1-14	Common summer resident. Casual winter resident.
Grosbeak, Red-breasted	5-2	5-1	5-2	5-7	5-4	4-29	5-2	5-1	5-2	5-1	5-10	5-1	5-2	5-5	5-1	4-30	Summer resident; not abundant.
Heron, Green									5-3	5-5	4-27	5-12	5-6	5-21	5-1	5-10	Summer resident; nests in bushes or trees adjacent to swamps.
Hummingbird, Ruby-throated	5-13	5-16	5-14	5-16	5-7	5-18	5-13			5-6	5-16	5-7	5-30	5-21	5-5	5-7	Common summer resident.
Kingbird	5-1	4-27	4-30	5-6	4-30	4-29	4-29	4-26	5-1	4-30	5-4	5-3	5-7	5-3	5-2	4-27	Common summer resident.
Kinglet, Golden-crowned	1-14	1-1	2-7	3-1	2-10	4-1	2-10	1-12	4-8	4-6	4-30	4-21	3-18	4-4	3-23	4-4	Winter resident and migrant.
Kinglet, Ruby-crowned	4-27		5-2	5-12	4-30		5-4	5-6			4-17	4-24	4-18	4-25	4-12	4-15	Spring and fall migrant. Nests in Canada.
Martin, Purple	3-26	3-26	4-2	3-24	4-9	4-13	4-28	4-7	4-9	4-3	4-6	4-13	4-11	3-24	4-22	4-12	Summer resident. Common in cities and villages.
Meadowlark	1-2	2-6	3-5	3-2		1-?	3-11	3-11	3-6	3-10	3-4	2-28	3-6	3-7	3-7	2-22	Abundant summer resident. Winter resident in southern Ohio.
Nighthawk	5-17	5-8	5-11	5-7	5-8	5-12	5-19	5-15		5-26	5-18	5-4	5-8	5-7	5-12	5-15	Abundant migrant; sparing summer resident.
Nuthatch, Red-breasted			10-16	5-10		1-?	1-?	1-1			5-4	5-7					Spring and fall migrant. Occasional winter resident in southern portion.
Oriole, Orchard	5-4	5-1	5-3	5-8	4-30	4-21	5-10	5-10		5-3	5-4	5-1	5-7	5-5	5-2	4-30	Summer resident; not numerous.
Oriole, Baltimore	5-1	4-27	4-29	5-3	4-29	4-28	4-30	4-25	4-26	4-24	5-1	4-30	4-29	5-2	4-28	4-27	Common summer resident.
Ovenbird	5-14	5-12	5-2	5-15	5-4		4-28	5-7		5-5	5-20	5-7	4-18	4-30	4-28	5-11	Abundant summer resident.
Pewee, Wood	5-7	5-4	5-12	5-6	5-6	5-13	5-12	5-16		5-12	5-7	5-4	5-11	5-7	5-6	5-7	Abundant summer resident.
Phoebe	3-21	3-15	3-17	3-24	3-18	4-1	3-17	3-13	4-8	4-16	3-19	3-15	3-21	3-22	3-22	3-27	Common summer resident.
Redstart, American	5-18	5-12	5-8	5-15	5-2	5-2	5-11	5-11			5-18	5-4	5-2	5-7	5-2	5-7	Summer resident; most numerous during migration period.
Robin, American	2-3	1-8	1-16	1-13	1-22	1-2	2-17	1-19	1-14	1-18	2-15	2-23	1-1	2-13		1-14	Abundant summer resident; occasional winter resident.
Sapsucker, Yellow-bellied									3-11	3-3	1-14	4-11	4-6	4-23	4-7	4-15	Common migrant in spring and fall.
Shrike, Northern	2-9																Migrant in spring and fall; occasional winter resident.
Shrike, White-rumped	3-19	3-9	3-11	4-24	4-27		4-8		4-8	4-6	5-3		5-16		5-1	4-7	Summer resident.

RECORDS OF BIRD MIGRATION. Continued.

	Date of record—Harry.								Date of record—Good.								
	1901	1902	1903	1904	1905	1906	1907	1908	1899	1900	1901	1902	1903	1904	1905	1906	
Sparrow, Chipping	4-11	4-5	3-19	3-29	3-26	4-5	3-24	3-27	4-12	4-8	4-5	3-28	3-23	3-25	3-23	4-2	Summer resident; winter resident in southern portion of state.
Sparrow, Field	3-25	3-24	3-18	3-24	3-22	4-4	3-23	3-18	4-15	4-7	3-28	3-22	3-18	3-23	3-18	4-4	Common summer resident.
Sparrow, Fox	11-9		4-18	5-15	3-25		3-31					4-11	4-11	4-4	3-25	4-2	Common fall and spring migrant.
Sparrow, Grasshopper	4-26	4-24	4-25	5-12	4-27	4-29	4-28	5-3		5-12	4-25	4-25	4-22	4-23	4-13	4-14	Common summer resident.
Sparrow, Lark	6-10											5-30					Summer resident in southern Ohio. Not plentiful.
Sparrow, Song	1-1	1-5	1-?	1-?	1-?	1-?	1-?	1-1									Resident all over state; sparingly so in northern Ohio
Sparrow, Swamp		2-15	5-2				4-28										Common migrant; casual resident.
Sparrow, Vesper	3-25	3-26	3-18	3-24	3-25	4-4	3-21	3-22	4-6	4-18	3-28	3-22	3-18	3-22	3-23	4-2	Abundant summer resident.
Sparrow, White-crowned	5-4	5-11	5-10	5-8	4-30	5-2	5-11	5-10	5-9	5-12	5-4	5-3	5-14	5-7	5-5	5-7	Spring and fall migrant.
Sparrow, White-throated	5-4	4-27	4-25	4-26	4-21	4-16	4-21	4-22	5-4	5-8	5-4	5-3	4-29	4-30	4-13	4-25	Abundant spring and fall migrant. Winter resident in southern Ohio.
Swallow, Barn	4-13	4-16	4-16	4-17	4-21	4-13	4-24	4-19	4-12	4-16	4-10	4-14	4-11	4-23	4-20	4-21	Summer resident. Less plentiful than formerly.
Swallow, Cliff	5-13	5-9	4 25	4-24	5-30		5-11					4-28	5-13	5-7	5-13	4-30	Summer resident. Not common.
Swallow, Rough-winged	4-28	5-17	5-2				·	5-3	5-2	4-28	4-27	5-1	4-18	4-30	5-1	5-3	Resident. Usually found along streams.
Swallow, Tree		4-14	5-3									5-14					Spring and fall migrant. Occasional summer resident.
Tanager, Scarlet	5-4	5-1	5-2	5-8	5-4	5-6	5-12	5-14	5-24	5-5	5-9	5-12	5-2	5-5	5-5	4-27	Summer resident.
Thrasher, Brown	4-26	4-22	4-10	5-1	4-21	4-24	4-28	4-12	4-15	4-18	4-16	5-1	4-17	4-23	4-15	4-13	Summer resident. Not numerous.
Thrush, Hermit	4-12	4-14	5-2	5-8	4-30		4-21	4-12		4-21	4-13	5-4	4-22	4-23	4-13	4-26	Spring and fall migrant.
Thrush, Louisiana Water	7-31		4-25	5-8	5-21	4-29	4-21	4-12								4-14	Summer resident; found along streams and in wild spots.
Thrush, Olive-backed				5-12			5-13							5-7	5-20		Spring and fall migrant.
Thrush, Water	9-26	5-17					5-3										Common migrant, usually follows streams or woodland swamps.
Thrush, Wilson's			5-4	5-15	5-7		5-15	5-10				5-14			5-2	5-7	Common migrant. Occasional summer resident, especially in northern Ohio.
Thrush Wood	5-1	5-1	5-2	5-6	4-29	5-13	5-12	5-3		5-5	4-30	4-28	5-7	4-30	4-28	4-30	Common summer resident.
Vireo, Blue-headed	5-15	4-25			5-4									5-7	5-5	5-11	Common spring and fall migrant.
Vireo, Red-eyed	5-13	5-6	5-15	5-8	5-7	4-?	5-18	5-15	5-13	5-30	5-11	4-28	5-8	5-7	5-1	4-30	Abundant summer resident.
Vireo, Warbling	4-30								4-26	4-23	4-29	4-22	4-29	5-2	4-28	4-27	Summer resident: most common northerly.
Vireo, White-eyed		5-2															Summer resident in southern Ohio; rare in northern part of state.

	Date of record—Harry.								Date of record—Good.								
	1901	1902	1903	1904	1905	1906	1907	1908	1899	1900	1901	1902	1903	1904	1905	1906	
Vireo, Yellow-throated	5-1	5-12	5-4	5-8	5-3	4-29	4-28	5-3									Summer resident; common during migration.
Warbler, Black and White	5-4	5-1	5-4	5-12	4-29		5-11	5-5	5-9	5-5	5-4	4-28	5 6	5-5	5-1	5-4	Common migrant; occasional summer resident.
Warbler, Bay-breasted	5-18	5-13		5-12			5-19	5-16		5-9	5-20	5-13	5-13	5-7		5-14	Regular spring and fall migrant, not numerous.
Warbler, Blackburnian	5-23	5-2	5-12	5-12			5-16	5-16			5-18	5-7	5-13	5-7	5-1	5-4	Abundant spring and fall migrant.
Warbler, Black-throated Blue	5-8	5-10	5-4	5-9	5-5	5-6	5-11			5-7	5-20	5-1	5-6	5-5	5-1	5-7	Common spring and fall migrant.
Warbler, Black-throated Green	5-5	5-2	4-29	5-3	4-30	5-13	4-29	5-3			5-20	5-4	5-18	5-7	5-1	4-30	Common spring and fall migrant. Rare summer resident north.
Warbler, Black Poll					5-21		5-26	5-15		5-7							Late spring and early fall migrant.
Warbler, Blue-winged		6-10	5-15	5-8	5-7	4-29							5-13	5-7	5-2	4-30	Summer resident.
Warbler, Cape May			9-27	5-16	5-7											5-13	Rather uncommon migrant.
Warbler, Canadian			5-15	5-15		5-6	5-11				5-18		5-20			5-7	Common spring and early fall migrant.
Warbler, Cerulean			5-15														Common migrant. Occasional summer resident.
Warbler, Chestnut-sided	5-15	5-12	5-12	5-6	5-4	5-14	5-14	5-16		5-12	5 18	5-4	5-13	5-7	5-5		Common migrant. Rare summer resident in northern part of state.
Warbler, Connecticut			5-21														Rare migrant.
Warbler, Golden-winged													5-14			5-7	Migrant. Rare summer resident in northern part of state.
Warbler, Kentucky			5-21														Summer resident in southern Ohio. Rare elsewhere
Warbler, (Northern Maryland) Yellow-throat	5-13	5-4	5-2	5-8	5-2	4-29	4-28	5-3	5-9	5-5	5-4	4-28	5-6	5-5	5-1	4-30	Common summer resident in swamps and lowland thickets.
Warbler, Magnolia	5-15	5-12	5-4	5-10	5-4		5-13			5-9	5-9	5-1	5-13	5-7	5-5	5-13	Common spring and fall migrant.
Warbler, Mourning				5-15													Common spring and fall migrant.
Warbler, Myrtle	5-1	4-25	5-2	4-30	4-27	4-30	4-30	4-22		5-12	5-4	5-8	5-7	5-7	5-1	4-21	Common migrant in spring and fall.
Warbler, Nashville											5-6		5-7	5-7		5-4	Common spring and fall migrant.
Warbler, Palm			5-3												5-1	4-30	Common migrant in spring and fall.
Warbler, Parula		5-2	5-8				5-11							5-7			Rare migrant. One form is summer resident. Not common.
Warbler, Tennessee				5-18													Common spring and fall migrant.
Warbler, Wilson's	5-22	5-12		5-15			5-19				5-20	5-14	5-12				Spring and fall migrant. Found in thickets.

RECORDS OF BIRD MIGRATION. Concluded.

	Date of record—Harry.								Date of record—Good.								
	1901	1902	1903	1904	1905	1906	1907	1908	1899	1900	1901	1902	1903	1904	1905	1906	
Warbler, Yellow.......	4-28	4-27	4-28	4-27	4-21	4-25	4-29	4-23	4-24	4-23	4-27	4-24	4-28	4-30	4-25	4-21	Rather common summer resident.
Warbler, Yellow-throated (Sycamore).				5-13													Sparse summer resident in southern half of state.
Waxwing, Cedar......	3-18	2-6	5-2	5-26	1-9	3-?		2-28									Summer resident and not uncommon in winter.
Whip-poor-will.........	5-6	5-15	5-9	5-28	5-14	5-14	5-15	5-16			6-12	5-1				5-14	Not uncommon summer resident.
Woodpecker, Red-headed									1-1	5-5	5-4	5-19	1-1	1-2	3-2	4-27	Common in summer, not rare in winter.
Wren, Carolina..	1-17	1-19		2-7	1-12	1-21	1-?	1-1									Rare in northern Ohio. Common and resident elsewhere.
Wren, House...........	5-2	4-25	4-13	4-28	4-23	4-22	4-28	4-20	5-5	4-28	5-2	4-23	4-18	4-25	4-22	4-26	Common summer resident.
Wren, Winter..........	2-15		4-25	4-19			4-28	5-3									Migrant in November to southward. Casual in winter.

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CIRCULAR NO. 75, REVISED EDITION. Issued July 24, 1908.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

REQUIREMENTS TO BE COMPLIED WITH BY NURSERYMEN OR OTHERS WHO MAKE INTERSTATE SHIPMENTS OF NURSERY STOCK.

By A. F. BURGESS,
Expert in Breeding Experiments.

For the information of nurserymen or other persons who desire to ship nursery stock to points outside the States in which their nurseries are located a brief statement of the requirements is given herewith. Changes are continually being made on account of the enactment of new laws or the amendment of old ones, and modifications of the regulations of different States are made from time to time by the authorities in charge of the enforcement of the laws. On this account Circular No. 75 has been revised and the requirements given are in force on the date of its publication. For the convenience of nurserymen who may wish to write to the officials in charge of inspection work the names and addresses of the latter are given.

Alabama.—Persons shipping stock into the State must file a signed duplicate certificate of inspection and obtain official tags, which must be placed on each shipment, in addition to a copy of the certificate. Cost of tags, 60 cents per hundred, or $2.25 per thousand. Five cents per hundred must be added for postage. Mr. R. S. Mackintosh, State Horticulturist, Auburn, Ala. (Act of 1903.)

Arizona.—The University of Arizona Agricultural Experiment Station is authorized to inspect all palms or palm stock growing in or shipped into the Territory. Prof. R. H. Forbes, Director, Agricultural Experiment Station, Tucson, Ariz. (Act of 1907.)

Arkansas.—Shipments must bear a certificate of inspection. Mr. C. F. Adams, State Inspector, Fayetteville, Ark. (Act of 1903.)

California.—Shipments of stock sent into the State are subject to inspection and must bear the name of the consignor and consignee and a statement of where the stock was grown. Notice of shipments should be made to Hon. J. W. Jeffrey, Commissioner of Horticulture, Sacramento, Cal.

Colorado.—Shipments into the State must be inspected by county inspectors. (Amended act of 1897.)

Connecticut.—Shipments of stock into the State must bear certificates of inspection, issued by a State or Government officer, and a statement by the owner that they have been thoroughly fumigated. Dr. W. E. Britton, State Entomologist, New Haven, Conn. (Amended act of 1903.)

Delaware.—Shipments into the State must be accompanied by a certificate of inspection of a State or Government official and the owner or shipper must certify that the stock has been fumigated. Delaware nurserymen are required to fumigate their stock. Mr. Wesley Webb, Dover, Del. (Amended act of 1901.)

Florida.—It is unlawful for any nonresident person or persons, corporation or firm, to sell or offer for sale nursery stock in the State of Florida without first having paid a license tax of $25 annually to the collector of revenues of the county in which the stock is sold or offered for sale. Upon payment of this amount a license will be issued by the county judge. (Act of 1905.) It is unlawful for any person to knowingly sell or give away diseased nursery stock or seeds in the State of Florida. Dr. E. W. Berger, Entomologist, Florida Agricultural Experiment Station, Gainesville, Fla. (Act of 1906.)

Georgia.—Shipments into the State must be accompanied with certificates of inspection and copies of the official tags of the State Board of Entomology. These may be obtained by submitting a duplicate of the official certificate of inspection and a statement that all stock shipped into the State will be properly fumigated. Tags are furnished at cost. Mr. E. L. Worsham, State Entomologist, Atlanta, Ga. (Act of 1900.)

Hawaii.—Shipments are subject to the regulations of the Board of Commissioners of Agriculture and Forestry and are subject to inspection and quarantine on arrival at Honolulu, which is the only port where they are allowed to be landed. For application blanks for inspection and special information, address Hon. C. S. Holloway, Secretary, Honolulu, Hawaii.

Idaho.—Persons desiring to sell or ship stock into this State must file a bond in the sum of $1,000 with the State Board of Horticulture, conditioned on the faithful compliance with the requirements of the law, and secure a permit to do business in the State. Shipments must bear official certificates of fumigation, and the name of the grower and consignee must appear on the package. Mr. J. R. Field, State Horticultural Inspector, Boise, Idaho.

Illinois.—Shipments into the State must be accompanied with certificates of inspection. The State Entomologist is required by law to furnish annually to Illinois nurserymen a list of State and Government inspectors whose certificates may be received as equally valid with his own, and the nurserymen receiving stock under such certificates are authorized to substitute the Illinois certificate of inspection. Agents and dealers must file sworn statements with copies of certificates showing the source from which their stock is obtained, for the approval of the State Entomologist. Dr. S. A. Forbes, State Entomologist, Urbana, Ill. (Act of 1907.)

Indiana.—Stock shipped into the State must be accompanied with certificates of inspection and each shipment must bear the name of the consignor and consignee. It is unlawful for any transportation company to accept for shipment or to deliver any uncertified nursery stock. Mr. Benjamin W. Douglass, State Entomologist, Indianapolis, Ind. (Act of 1907.)

Iowa.—Shipments into the State must be accompanied by official certificates of inspection, copies of which should be previously filed for approval with the State Entomologist. Prof. H. E. Summers, State Entomologist, Ames, Iowa. (Amended act of 1906.)

Kansas.—Stock shipped into the State must be accompanied by certificates of inspection. Prof. S. J. Hunter, Lawrence, Kans., and Prof. T. J. Headlee, Manhattan, Kans., State Entomologists. (Act of 1907.)

Kentucky.—Shipments into the State must be accompanied with official certificates of inspection, copies of which should be filed with the State Entomologist. Prof. H. Garman, State Entomologist, Lexington, Ky. (Act of 1897.)

Louisiana.—Shipments sent into the State must be accompanied with official certificates of inspection. When a shipment containing two or more orders is sent to an agent or dealer for delivery to different persons, a certificate must accompany each individual order. Mr. Wilmon Newell, Entomologist, State Crop Pest Commission, Baton Rouge, La. (Act of 1903, Regulations of State Crop Pest Commission, approved April 11, 1907.)

Maine.—Shipments into the State must bear official certificates of inspection or affidavits that the contents have been fumigated in a manner approved by the State inspector of the shipping point. Hon. A. W. Gilman, Commissioner of Agriculture, Augusta, Me. (Act of 1907.)

Maryland.—Stock sent into the State must bear the name of the consignor and consignee and a certificate of inspection. Duplicate certificates should be filed with the State Entomologist. Prof. T. B. Symons, State Entomologist; Prof. J. B. S. Norton, State Pathologist, College Park, Md. (Act of 1898.)

Massachusetts.—Stock sent into the State must bear a certificate of inspection or an affidavit of fumigation. Dr. H. T. Fernald, State Nursery Inspector, Amherst, Mass. (Amended act of 1907.)

Michigan.—Nurserymen selling stock in this State must pay a license fee of $5 and furnish a bond of $1,000, with satisfactory sureties. Shipments must be accompanied with certificates of inspection and, if of species subject to the attack of the San Jose scale, certificates by the nurserymen that the stock has been properly fumigated. Prof. L. R. Taft, State Inspector of Orchards and Nurseries, Agricultural College, Mich. (Amended act of 1905.)

Minnesota.—Stock shipped into the State must bear a certificate of inspection. Prof. F. L. Washburn, State Entomologist, St. Anthony Park, Minn. (Act of 1903.)

Mississippi.—Before shipping stock into the State a copy of an official certificate of inspection must be filed with the Entomologist of the Experiment Station, which must state that in addition to the regular inspection the stock has been fumigated under the direction of the official issuing the certificate. Failure to comply with this requirement renders the stock liable to confiscation and destruction. All shipments must be accompanied with such a certificate. Prof. Glenn W. Herrick, Experiment Station, Agricultural College, Miss. (Act of 1908.)

Missouri.—Stock shipped into the State must bear the name of the consignor and the consignee and a statement of the contents and an official certificate of inspection. Prof. J. M. Stedman, State Entomologist, Agricultural Experiment Station, Columbia, Mo.

Montana.—All stock brought into the State must be unpacked, inspected, and if necessary fumigated at one of the designated quarantine stations, viz: Miles City, Billings, Dillon, Missoula, Kalispell, Great Falls, Troy, Plains, Glasgow, or Thompson Falls. Nursery stock may be inspected, and if necessary fumigated, at other points of delivery on payment of all cost. To sell or deliver nursery stock it is necessary first to obtain a license by paying a fee of $25 and by filing with the Secretary of the State Board of Horticulture a bond in the sum of $1,000 annually. Notice of shipment, including an invoice of stock, must be sent to Mr. Joseph W. Wallisch, Secretary, Montana State Board of Horticulture, Hirbour Block, Butte, Mont. (Act of 1899.)

Nebraska.—No nursery-inspection law. Local nurseries inspected and certificates issued by Prof. Lawrence Bruner, Acting State Entomologist, Lincoln, Nebr.

Nevada.—No law.

New Hampshire.—Stock shipped into the State must bear a certificate of inspection or a statement containing an affidavit that it has been properly fumigated. Prof. E. D. Sanderson, State Nursery Inspector, Durham, N. H. (Act of 1903.)

New Jersey.—Stock shipped into the State must be accompanied with a certificate of inspection and a statement from the shipper that it is a part of the stock inspected and whether it has been fumigated with hydrocyanic-acid gas. Dr. John B. Smith, State Entomologist, New Brunswick, N. J. (Act of 1903.)

New Mexico.—No law relating to nursery inspection.

New York.—Nursery stock shipped into the State must be accompanied with an official certificate of inspection and must be fumigated before being sold or planted. Hon. Charles A. Wieting, Commissioner of Agriculture, Albany, N. Y. (Act of 1903.)

North Carolina.—Shipments sent into this State must bear official certificates of inspection and should be fumigated and a statement to that effect signed and attached by the consignor. Duplicate certificates must be filed with the State Entomologist. Franklin Sherman, jr., State Entomologist, Raleigh, N. C. (Act of 1897.)

North Dakota.—No law.

Ohio.—Shipments must be accompanied with official certificates of inspection or fumigation. Agents and dealers must file sworn statements as to sources from which their stock is obtained. Mr. N. E. Shaw, Chief Inspector, Department of Agriculture, Columbus, Ohio.

Oklahoma.—The owners or operators of nurseries who desire to ship stock into the State of Oklahoma are required to make an application for a permit. This will be issued by the Board of Agriculture upon the filing of a duplicate certificate of inspection or the report of inspection from the State inspector who examined the stock, and in addition the application must be accompanied by a remittance of $5. If satisfactory, the Board will issue a permit over the signature of its Secretary, and in addition to the above may require further evidence of integrity to establish the responsibility and good faith of the applicant. All shipments must be accompanied by a tag on which is printed a copy of this permit over the facsimile signature of the Secretary of the Board. All agents canvassing for nurseries located outside the State are required to carry a duplicate of the permit of their principals, which duplicate is issued upon payment of $1. Quotations on tags will be forwarded upon application to the Secretary. Address all communications to Oklahoma State Board of Agriculture, C. F. Barrett, Secretary, Guthrie, Okla. (Act of 1905.)

Oregon.—Stock is subject to inspection on arrival at quarantine stations. Mr. H. W. Williamson, Secretary, State Board of Horticulture, Portland, Oreg. (Amended act of 1905.)

Pennsylvania.—Shipments of nursery stock into the State must be plainly labeled on the outside with the name of the consignor and consignee, and a certificate showing that the contents have been inspected and that the stock (excepting conifers and herbaceous plants) therein contained have been properly fumigated. Dealers in nursery stock are furnished certificates under certain restrictions. Transportation companies are required to reject all stock entering the State unless certificates of inspection and fumigation are attached. Prof. H. A. Surface, Economic Zoologist; Mr. E. B. Engle, Inspector, Harrisburg, Pa. (Act of 1905.)

Porto Rico.—Nursery stock will be received only through three ports of entry, namely, San Juan, Ponce, and Mayaguez, and must be accompanied with an official certificate of inspection. It is subject to inspection by local inspectors on arrival at said ports of entry. Inspectors are appointed by the Governor. (Act of 1905.)

Rhode Island.—Shipments must be accompanied with certificates of inspection or affidavits of fumigation. Mr. A. E. Stene, State Nursery Inspector, Kingston, R. I. (Act of 1904.)

South Carolina.—A duplicate certificate of inspection must be filed with the State Entomologist and an official tag of the State Board of Entomology secured by nurserymen desiring to ship stock into the State. This tag and an official certificate of fumigation must be attached to all shipments. Prof. C. E. Chambliss, State Entomologist, Columbia, S. C. (Act of 1903.)

South Dakota.—Shipments into the State must be accompanied with official certificates of inspection. A license fee of $10 must be paid to secure a permit to ship stock into the State. Mr. Robert Mathieson, State Entomologist, Brookings, S. Dak. (Act of 1907.)

Tennessee.—A certificate of inspection signed in person by the inspector or the State Entomologist must be filed in the office of the Tennessee State Board of Entomology, Knoxville, Tenn., previous to all shipments. All nursery stock must be fumigated and a tag indicating the same placed upon each shipment. Prof. H. A. Morgan, State Entomologist, Knoxville, Tenn. (Act of 1905.)

Texas.—Duplicate certificates of inspection must be filed, and all shipments must bear certificates of inspection. Hon. R. T. Milner, Commissioner of Agriculture, Austin, Tex. (Act of 1905.)

Utah.—All stock shipped into the State must bear an official certificate stating that it has been fumigated with hydrocyanic-acid gas. Nurserymen doing business in the State must pay a license fee and file a bond with the State Board of Horticulture in the sum of $500. License fees are graded as follows: Any annual business below $1,000, $5 per year; over $1,000 and under $3,000, $10 per year: over $3,000 and under $10,000, $25 per year; over $10,000, $50 per year. Mr. J. Edward Taylor, Secretary, State Board of Horticulture, Salt Lake City, Utah.

Vermont.—No law.

Virginia.—Duplicate certificates of inspection must be filed by nurserymen shipping stock into the State and official tags obtained from the Board of Crop Pest Commissioners; also a registration fee of $20 must be paid. Tags furnished at cost. Mr. J. L. Phillips, State Entomologist, Blacksburg, Va. (Amended act of 1903.)

Washington.—Before soliciting or engaging in selling nursery stock in this State a bond of $1,000 and a license fee of $5 must be paid by nurserymen and a license fee of $2.50 by agents and dealers. Notice must be sent previous to the shipment of stock, giving the names of the nurserymen and the places at which it is to be delivered. Hon. F. A. Huntley, Commissioner of Horticulture, Tacoma, Wash. (Act of 1907.)

West Virginia.—All stock shipments into the State must be accompanied by an official certificate of inspection and fumigation. Notice of shipments must be sent, ten days before the time of delivery, to the Director of the West Virginia Experiment Station, stating the number of trees in each consignment, the place from which such are to be shipped, and their destination. Agents and dealers who sell stock must secure a license from the assessor in the county where the stock is sold and pay a fee of $10 to the sheriff of the county. Prof. J. H. Stewart, Director of Agricultural Experiment Station, Morgantown, W. Va. (Amended acts of 1905 and 1907.)

Wisconsin.—Stock shipped into the State must be accompanied with an official certificate of inspection. Prof. E. P. Sandsten, Agricultural Experiment Station, Madison, Wis. (Act of 1907.)

Wyoming.—Any person or firm wishing to do business in the State must first obtain a license. Licenses are issued on application, for a period terminating on July 1 of the next succeeding inspection year (approximately two years). All applications must be accompanied by the license fee ($25), a bond in the sum of $500 conditioned that the principal will faithfully obey the law of the State of Wyoming, and by a certified certificate of inspection from an authorized inspector in the State from which shipments are to be made. On receipt of these, the Secretary of the State Board issues authorized shipping tags (at cost). Nursery stock may not enter the State and transportation companies may not deliver unless such tags be attached to each and every box, bundle, or bale. For circular of detailed information address Prof. Aven Nelson, Secretary State Board of Horticulture, Laramie, Wyo. (Act of 1905.)

Canada.—Shipments of stock into Canada are unpacked and fumigated by government inspectors and must arrive within the time specified at the following ports of entry: St. Johns, Quebec; Niagara Falls, Ontario, and Windsor, Ontario, from March 15 to May 15 and from September 26 to December 7; St. John, New Brunswick, and Winnipeg, Manitoba, from March 15 to May 15 and from October 7 to December 7; Vancouver, British Columbia, from October 1 to May 1. Dr. James Fletcher, Dominion Entomologist, Ottawa, Ontario.

Approved:
JAMES WILSON,
Secretary of Agriculture.
WASHINGTON, D. C., *June 9, 1908.*

[Cir. 75.]

O

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF ENTOMOLOGY—BULLETIN NO. 34, NEW SERIES.

L. O. HOWARD, Entomologist.

PRINCIPAL INSECTS LIABLE TO BE DISTRIBUTED ON NURSERY STOCK.

PREPARED UNDER THE DIRECTION OF THE ENTOMOLOGIST,

BY

NATHAN BANKS,
Assistant Entomologist.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., April 29, 1902.

Sir: I have the honor to transmit for publication a manuscript prepared by Mr. Nathan Banks, of this office, in which are considered the principal insects liable to be distributed upon nursery stock. The inspection of nursery stock under State laws has become so general throughout the United States that the desirability of some publication of this sort has become very evident. I had the matter in mind last autumn, and at a conference of the official horticultural inspectors for the United States, held at Washington October 11–13, 1901, a resolution was unanimously passed requesting this Department to prepare and publish an article on those nursery pests of the country which are capable of transmission on nursery stock to the injury of the purchasers. Since it is desirable that this manuscript shall be put in available shape for distribution to all horticultural inspectors and to all nurserymen and others immediately interested, I recommend that it be issued as Bulletin No. 34, new series, of this Division.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

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THE PRINCIPAL INSECTS LIABLE TO BE DISTRIBUTED ON NURSERY STOCK.

INTRODUCTION.

In preparing this descriptive catalogue of the insects liable to be transported upon nursery stock, it has appeared that there is a great disparity of views as to what insects should be included. To include only such as are known to be very destructive would exclude a great many species that will be found by anyone who examines a tree in the fall or early spring. To include all the species that are known to be found in any stage upon fruit trees in winter would make the list too bulky. Therefore, all species known to be of more than local interest have been treated. Notes on the species infesting fruits are added at the end. The insects have been arranged according to their natural orders, and in the Hemiptera (bugs, scale insects, plant-lice) according to the families. In the Coleoptera (beetles, weevils) and Lepidoptera (butterflies and moths), such an arrangement did not seem desirable. No account of the remedies to be recommended or used is given, as these differ greatly, according to locality and conditions, and the various State laws specify certain treatments.

It will be a great help to those interested in the growth and sale of young fruit trees to be able to recognize the appearance of the various insect pests during the winter; therefore, much attention has been paid to this phase of the subject.

In using this bulletin one should remember that, besides the insects here treated, there may be upon a tree other insects of less importance.

TABULAR STATEMENT OF INSECTS UPON THE TREE IN WINTER.

Insects upon the roots:	
Forming swellings on apple roots	Woolly aphis.
On peach and plum roots	Black peach aphis.
Insects upon the bark of trunk or branches:	
Plant-lice or aphids	Woolly aphis.
Small brown clear-winged insect in the crevices of bark	Pear psylla.
Scale insects or bark-lice	See Coccidæ.
Caterpillars in cases or cocoons	Fall webworm, bud moth, apple Bucculatrix, codling moth, pistol-case and cigar-case bearers.
In nests or bunches of shriveled leaves attached to branches	Leaf-crumpler, and brown-tail moth.

Insects upon the bark of trunk or branches—Continued.

- In a case or bag hanging from twigs .... Bagworm.
- Clusters of eggs on bark .... Cankerworms, tussock moth, and gipsy moth.
- A belt of eggs around twigs .... Apple-tree tent caterpillar.
- Single small blackish eggs often in groups on twigs or branches ...... Plant-lice.
- Smaller reddish eggs .... Clover mite.

Insects beneath the bark:

- Tiny holes usually near a crotch, each covered by a bit of frass .... Peach twig-borer.
- Small brown beetle within the twig .... Apple twig-borer.
- Small holes in bark of trunk or larger branches .... Fruit-tree bark-beetle.
- A gummy exudation of sap at base of tree .... Peach tree-borer.
- Discolored spots or cracks and evidences of frass .... Round-headed and flat-headed apple tree-borers, and sinuate pear borer.

TABULAR STATEMENT OF INSECTS FEEDING ON THE BUDS AND YOUNG LEAVES IN EARLY SPRING.

Feeding on the buds or young shoots.... Bud worm, peach twig-borer, leaf-crumpler, brown-tail moth, pistol-case and cigar-case bearers.

Feeding upon the leaves:

- Plant-lice .... Apple plant-lice, plum plant-louse, and cherry aphis.
- Caterpillars in tents .... Apple-tree tent caterpillar.
- Hairy caterpillars .... Tussock moth, brown-tail moth, gipsy moth.
- Bare caterpillars .... Canker worms.
- A blister or gall upon leaves .... Pear-leaf blister-mite.
- Small caterpillars within little cases .... Pistol-case bearer, cigar-case bearer, leaf-crumpler, and bagworm.

HEMIPTERA (BUGS, SCALE INSECTS, AND PLANT-LICE).

The members of this order obtain their food (which is liquid) by sucking it up a slender tube into the mouth cavity. This tube or beak is composed of several needle-like pieces so shaped and arranged that they inclose a minute channel up which the liquid food is drawn. The beak is inserted in the plant often to some distance beneath the surface. The members of this order do not pass through a pupal or chrysalis stage like the butterflies and moths, but there is an approach to it in the males of the scale insects. The insects of this order to be treated are arranged in four families, which may be separated, for our purposes, as follows:

The insect from above apparently without legs, antennæ, or wings, and fixed to the host plant; the adult male (not often seen) usually has two wings ...... Coccidæ. (scale insects).

The insect shows distinct legs and antennæ, and often four wings.

- Most of the specimens wingless, and provided with two small tubes or cornicles (see fig. 16) near tip of body; not hopping when disturbed .... Aphididæ (plant-lice).
- Adult always winged, without the cornicles; hopping when disturbed.
  - The prothorax not enlarged, with hyaline wings .... Psyllidæ.
  - The prothorax greatly enlarged; wings obscured .... Membracidæ.

FAMILY COCCIDÆ (SCALE INSECTS).

The scale insects, or bark-lice, are readily known from most insects in that the stages commonly seen are immovably fixed to the bark or leaf, and show no outward sign of legs or other structures. For a short time after birth they are active, crawling creatures, and distribute themselves over the surface of the plant. Having selected a location, they push their long and thread-like beaks deep into the tree and proceed to suck up the sap. As they grow the protected or covered bark-lice secrete a waxy substance that hardens and forms the scale. When the insect molts the old skin or exuvium remains attached to the scale. The shape, color, and position of this exuvium is of great value in identifying the species.

Their small size and similarity of appearance makes their determination difficult, and it is rarely safe to determine the species by a few individuals, but on a moderately infested branch one is apt to find some specimens that are quite characteristic of the species.

The unprotected bark-lice, such as the Lecaniums, secrete no covering scale.

TABLE OF SCALE INSECTS.

1. Soft scales, without a shield-like covering, very convex, on peach or plum. *Lecanium nigrofasciatum.*
2. Armored scales, with a shield-like covering and showing an exuvial spot, much less convex than Lecanium .... 3.
3. The exuvium shows as a circular spot situated near the center or at least remote from the edge of the scale; the adult female scale more or less circular, rarely whitish in color .... *Aspidiotus.*
4. The exuvium showing as a more or less ribbed, elliptical spot at the end or close to one edge of the scale; scales usually whitish in color; if not, then of an oyster-shell shape .... 5.
5. Scale brownish; the female of an oyster-shell shape, male ovate. *Mytilaspis pomorum.*
6. The scale whitish, female not oyster-shell shaped, male scale elongate .... 7.
7. The female scale plainly ovate, much longer than broad; the male scale having three longitudinal keels (see fig. 4, *d*) .... *Chionaspis furfurus.*
8. The female scale is irregularly circular, but little longer than broad; the male scale with one median keel .... 9.
9. Exuvium orange or bright yellowish; on fruit trees; male with keel rather indistinct .... *Diaspis pentagona.*
10. Exuvium pale or dull yellowish; on raspberry and blackberry; male with distinct keel .... *Aulacaspis rosæ.*

THE PEACH LECANIUM.

(*Lecanium nigrofasciatum* Perg.— fig. 1.)

This insect, formerly known as *L. persicae*, is one of the largest of the scale insects, being about one-fifth of an inch long and two thirds as wide. It is elliptical in outline and strongly convex. It is usually of a dull greenish-brown color, sometimes distinctly marked with darker bands. It is found upon the branches of peach and plum, more rarely on apple, and commonly occurs on the under side of the branch, the upper side of which is covered with a black fungus that grows on the honey-dew dropped by the Lecaniums from the branch above. The females pass the winter in the adult condition. The eggs are developed by the latter part of May. The young hatch early in June and continue for fully a month (June 10 to July 15). The young larvæ are flat, uniformly pale yellow, and with a thin marginal rim. They become stationary in a few weeks. By the middle of July the male pupæ are developed, and by the 22d the first winged males appear. There is but one brood a year, and the best time for treatment will be during July.

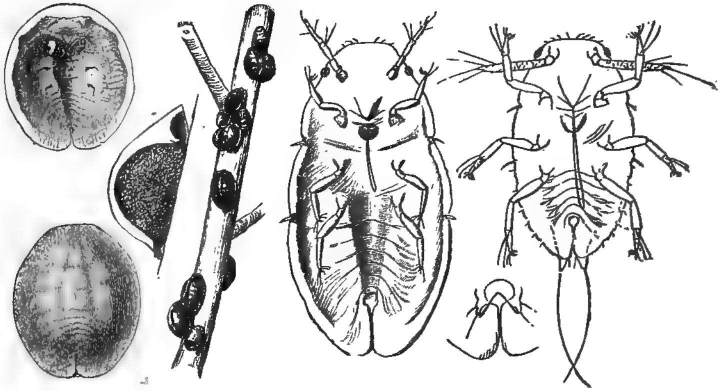

FIG. 1.—*Lecanium nigrofasciatum* Perg.: adults at left, young at right. (Howard).

There is another species of Lecanium (*L. prunastri*), less commonly found on plum. The female is much like that of the peach Lecanium, but the insect passes the winter in the larval state, not maturing till May. The young hatch in July, migrate to the leaves, and in the early fall return to the branches, where they pass the winter. It has rarely been found in this country outside of New York State.

THE OYSTER-SHELL BARK-LOUSE.

(*Mytilaspis pomorum* Linn.—figs. 2 and 3.)

The oyster-shell bark-louse is one of the best known enemies of the orchardist. It is a dark, slightly convex scale, elongate and usually curved in outline, much resembling a miniature oyster shell. When crowded upon the tree they are apt to be less curved and often quite straight. The elongate exuvium is situated at the small end. Its elongate shape and dark color at once separate it from all other common orchard scales. The eggs, which are whitish in color, are deposited in late summer, and occupy the posterior two-thirds of the scale. The female dies, but the scale remains to protect the eggs during the winter. The young hatch in May or early June, crawl out upon the

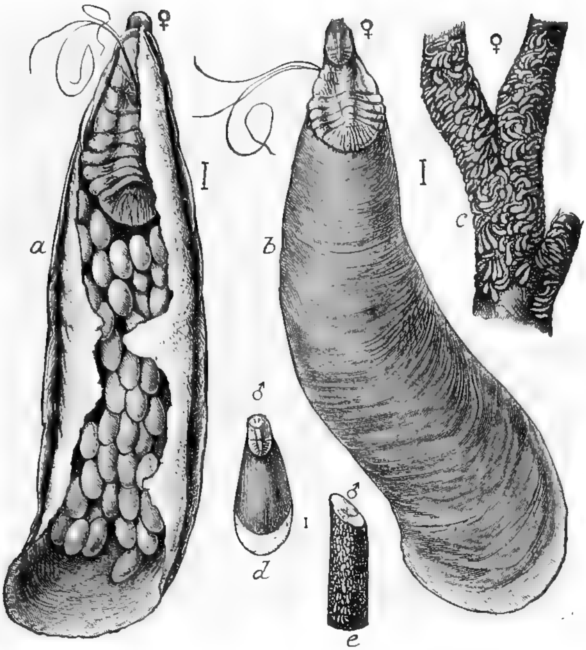

FIG. 2.—*Mytilaspis pomorum:* *a*, *b*, females; *c*, scales on twig; *d*, male scale. (Howard.)

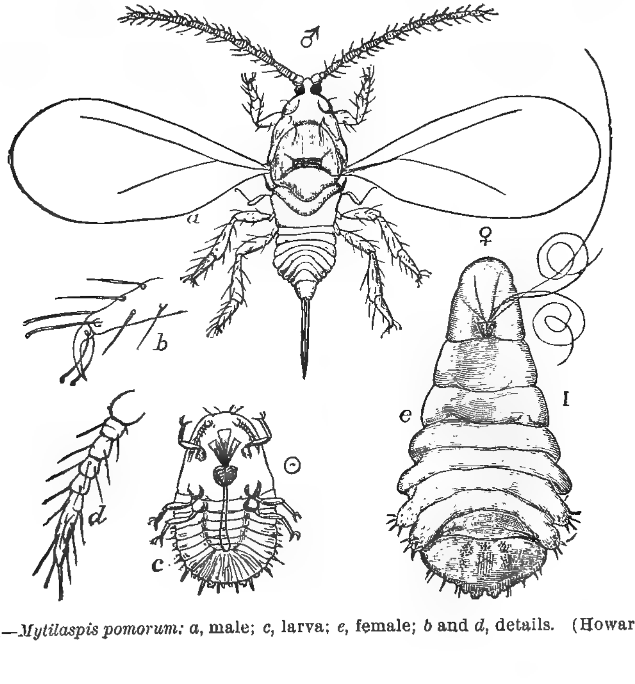

FIG. 3.—*Mytilaspis pomorum:* *a*, male; *c*, larva; *e*, female; *b* and *d*, details. (Howard.)

twigs and small branches, and locate there permanently. In a day or two they begin the formation of the scale. The male scale is much smaller than the female, elongate, wider behind than in front, and little, if any, curved. It is uncommon on apple, but often found on other food plants. The winged male insect appears in midsummer. There is but one brood a year in the North, but in parts of the South there are apparently two broods; the second one hatching about September 1. The oyster-shell bark-louse is widely distributed and attacks a great variety of trees, but is especially partial to apple.

THE SCURFY BARK-LOUSE.

(*Chionaspis furfurus* Fitch—fig. 4.)

This common orchard scale is readily known by its whitish color and ovate form. The adult female scale is rather flat, irregularly ovate in outline, with the yellowish exuvium at the apex. The life history is similar to that of the oyster-shell bark-louse. The eggs are laid in the early fall and occupy the greater part of the scale. The mother dies and the scale remains on the tree during the winter to protect the eggs. The young hatch during the latter part of May or early in June. The male scale, which is often very abundant, is much smaller than the female, snow-white in color, and fully twice as long as broad, with nearly parallel sides and three keels or ridges. The winged male insects issue in September. There is but one brood in the North, but probably two or even three in the South. The scurfy bark-louse is widely distributed and occurs on most orchard trees, but chiefly on apple and pear.

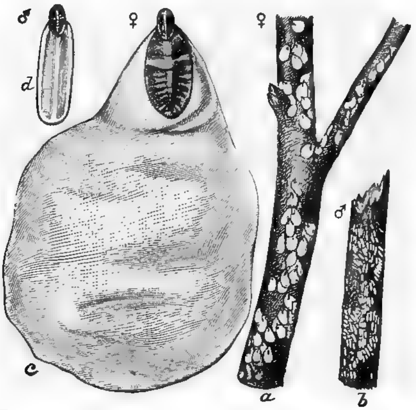

FIG. 4.—*Chionaspis furfurus:* *a*, *b*, infested twigs; *c*, female; *d*, male. (Howard.)

ASPIDIOTUS (CIRCULAR OR ROUND SCALES).

To this genus belongs the most destructive known species, the San Jose scale. The other species, however, often cause much damage. There is a considerable resemblance among the various species, so that it is difficult for any inexperienced person to determine them. The final characters that separate species are based on the structure of the pygidial plate of the adult female scale. To observe this it is necessary that a specimen be boiled in caustic potash and mounted in balsam on a glass slide. When this is examined under a microscope the lobes, spines, hairs, and sinuations of the margin of the plate appear quite distinctly. Thus, the characters that may be used in the field are not final and only comparative, and great care must be exercised, especially when only a small amount of material is available, and any doubt can be settled only by sending the material to some competent authority who can mount and microscopically examine the species.

TABLE OF ASPIDIOTUS.

1. Scale of adult female circular, with exuvium central, dark-colored, the exuvium pale yellowish when dark waxy outer covering is rubbed off; scale not very convex, about 2^{mm} in diameter; half-grown scales are nearly black and show a central nipple surrounded by one or two depressed rings.....*perniciosus* Comst.

Scale of adult female not circular, the exuvial spot at one side of the center; the half-grown scales usually paler and without the central nipple surrounded by depressed ring..........2.

2. Adult female scale dark-colored, about 2^{mm} in diameter; exuvial spot orange or reddish colored..........*A. forbesi, ancylus*, and *ostreæformis.*

Adult female scale paler, or larger, or with white center..........3.

3. Scale of adult female about 2^{mm} in diameter, yellowish or pale brownish, with a white center, quite flat; on grape..........*uvæ* Comst.

Scale of the adult female very convex, about $2\frac{1}{2}^{mm}$ in diameter, of a uniform drab or yellowish-brown color, the exuvial spot showing reddish, but not commonly exposed..........*rapax* Comst.

Scale of the adult female large, nearly 3^{mm} in diameter, flat, and pale-grayish in color; the exuvium reddish or orange..........*juglans-regiæ* Comst.

In identifying scale insects by means of the above table, scales should be examined from bark or fruit as clean as possible, and where the scales are not crowded and have room to normally develop. When thickly massed they lose their characteristic shape and appearance, and on sooty or dirty bark they are discolored and abnormal.

THE SAN JOSE SCALE.

(*Aspidiotus perniciosus* Comstock—figs. 5, 6, and 7.)

The San Jose scale is known to every orchardist by hearsay, but few, however, can distinguish it from allied scales, such as *ancylus*, *forbesi*, and *ostreæformis*. On badly infested trees the scale presents the appearance of dark gray, scurfy patches. The individual scale is about 2^{mm} in diameter, usually nearly circular in outline, of a grayish color, with the central darker nipple surrounded by one or more quite distinct yellowish or pale grayish rings. When the scales are crowded the outline is more or less distorted. In none of the allied forms is the adult female scale as nearly circular as in the San Jose scale. When on fruit or young twigs there is often a reddish discoloration around the scale. Putnam's scale and the cherry scale have a brighter colored exuvium, situate one side of the center. The cherry scale is often much paler than the San Jose scale. The European fruit scale has an exuvium similar to the San Jose, but lacks the darker nipple;

moreover, the exuvium is plainly not at the center of the scale. The male of the San Jose scale is about two times as long as broad; broader at one end than at the other, with a large, dark exuvium, showing a central nipple. It is situated toward the small end of the scale. The male of the European fruit scale is not so elongate, and the exuvium is but little darker than the scale and nearer to the small end than in the San Jose scale. The male of Putnam's scale is as elongate as that of San Jose, but has an orange exuvium. The male of the cherry scale is in shape much like that of the San Jose scale, but the exuvium is of a brighter yellow, the scale usually being paler than the San Jose.

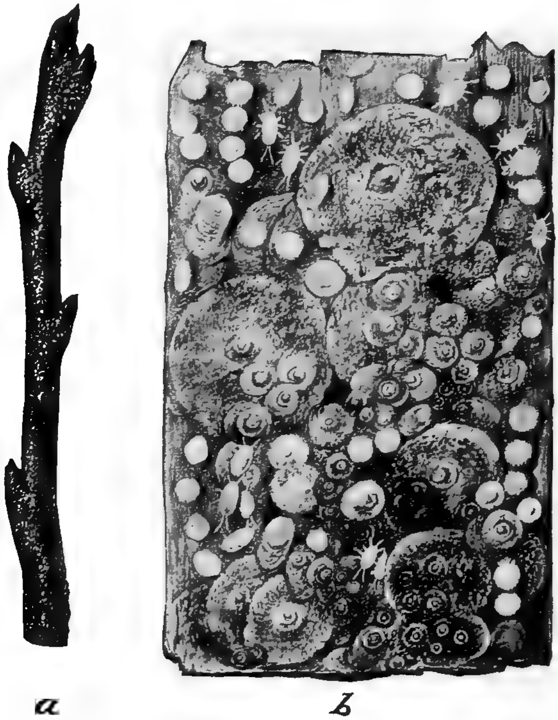

FIG. 5.—*Aspidiotus perniciosus: a*, infested twig; *b*, view of infested bark magnified. (Howard and Marlatt.)

In general the adult female of the San Jose scale may be distinguished from its allies by the more circular scale, with yellow exuvium, when exposed, more centrally located, otherwise with dark nipple; the male by similar characteristics of exuvium and nipple. But the San Jose scale is most easily recognized by its immature scales, which are almost black, circular, and with a central nipple surrounded by one or two depressed circular rings. Such a character is not found in any other of the allied scales.

The San Jose scale attacks all of our orchard trees, but appears to be most destructive to pear and peach. The insect is represented in winter by partly grown specimens whose development was stopped by the cold weather. They resume growth in the early spring; the males soon appear, mate with the females, and the latter give birth to living young. At Washington, D. C., this time is about the middle of May, and the young continue to appear for about six weeks. The larva crawls off a little way, settles, and within two days begins the secretion of its scale. This young scale is at first white with a swelling in the center. If it is situated on green tissue it is apt to produce a redness. In a few days the pale scale becomes nearly black, with a central nipple surrounded by one or two depressed rings. This form is very characteristic of the species. In about twenty-five days another brood of males appears, and in thirty days the females become adult. At about thirty-five or forty days of age the females begin to give birth to living young. Since one of these mother scales may have been born six weeks before another, it results that there is a

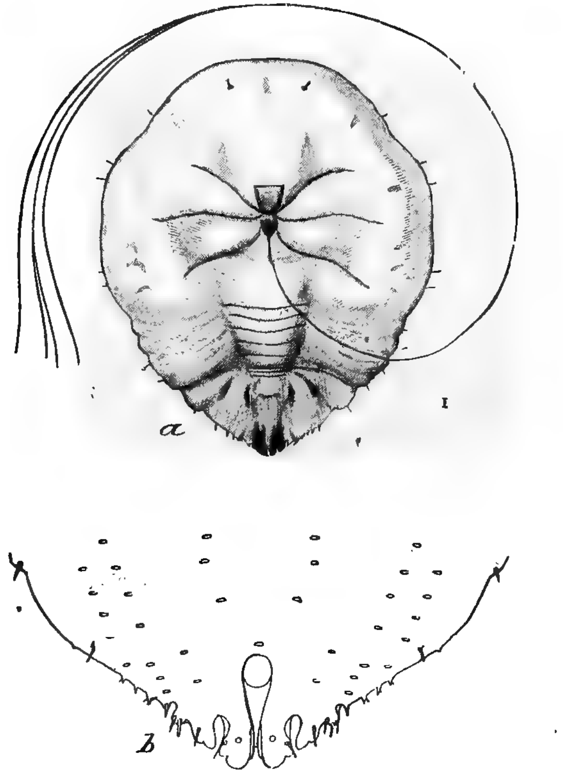

FIG. 6.—*Aspidiotus perniciosus: a*, female; *b*, margin of pygidium magnified. (Howard and Marlatt.)

confusion of generations throughout the summer, breeding constantly going on until late fall. The number of broods will thus depend upon the length of the season.

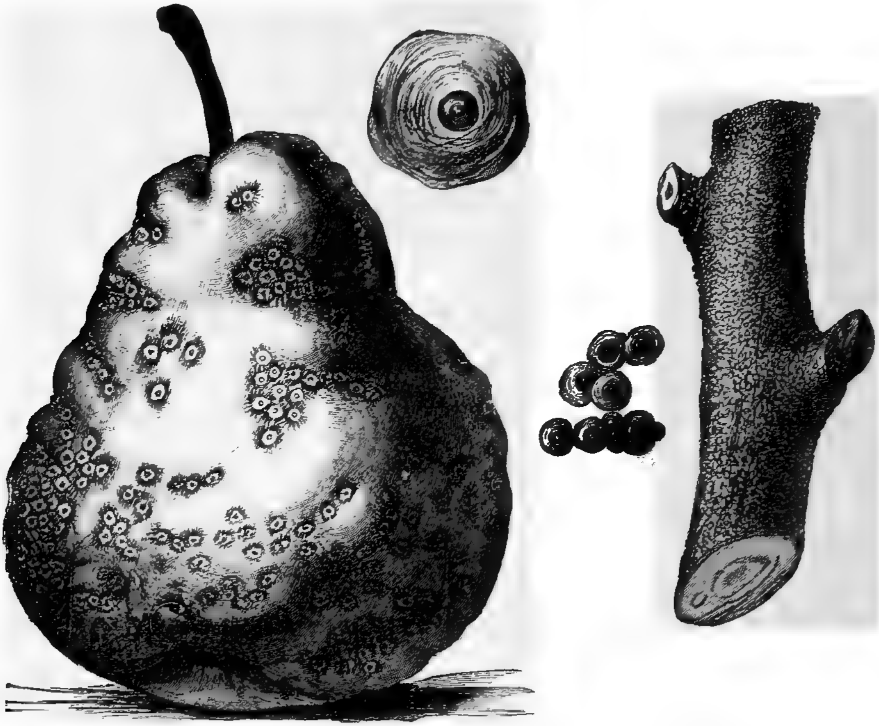

FIG. 7.—*Aspidiotus perniciosus:* Infested fruit and branch, and enlarged scales. (Howard.)

THE EUROPEAN FRUIT SCALE.

(*Aspidiotus ostreæformis* Curtis—fig. 8.)

This species can usually be readily separated from the San Jose scale by the characters mentioned under that species, but it is practically impossible, without making a microscopic mount, to distinguish it from Putnam's scale and the cherry scale. The cherry scale, especially when on cherry, is more shining and often shows a grayish margin. The European fruit scale occurs on all orchard trees, but only, so far as known, in certain Northern States. The winter is passed by the partly grown specimens, which become mature toward the last of June, and soon begin to give birth to living young. The young continue to appear for several weeks. There appears to be but one brood a year, at least in the Northern States.

PUTNAM'S SCALE.

(*Aspidiotus ancylus* Putnam.)

This scale is widely distributed and attacks all orchard trees. In general appearance it is like the San Jose scale, but at once known by the exposed orange exuvium, the less circular scale, and by the half-grown young having no depressed ring around the nipple. It can be separated from the European fruit scale and from the cherry scale only by a microscopic examination of mounted specimens. It is usually much darker than the cherry scale, the exuvium usually a brighter orange, and the scale more conical than that species. Specimens vary, however, a great deal in these points. The insect winters in a nearly full-grown condition. The males appear in April, soon pair with the females, and the latter deposit eggs in the late spring or early summer. The young begin to hatch early in July and continue during the month. There is but one brood a year.

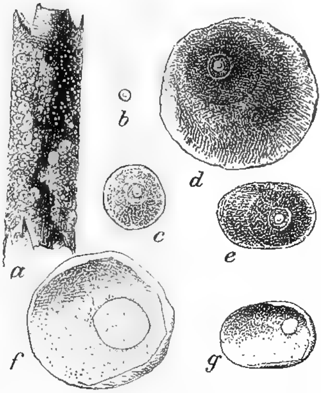

FIG. 8.—*Aspidiotus ostreæformis:* *a*, scales on twig; *b*, natural size; *c*, immature stage; *d*, female; *e*, male; *f* and *g*, inside of scales. (Marlatt.)

THE CHERRY SCALE.

(*Aspidiotus forbesi* Johnson.)

This scale is similar to Putnam's and to the European fruit scale, but sometimes, especially on cherry, it is more shining, and presents a gray rim around the scale, which is commonly flatter than the allied species. It attacks all orchard trees, but is rarely common. It winters partly grown, like its allies. The male issues in April. The eggs are laid in April or early May, the young hatching during May and part of June. There appears to be two broods a year, the males of the second brood issuing during the latter part of July and the young during August and September.

THE WALNUT SCALE.

(*Aspidiotus juglans-regiæ* Comstock—fig. 9.)

This insect is at once recognized by the large size of the adult female scale, it being the largest of our species of the genus, the scale often being 3^{mm} in diameter (one-twelfth inch), while the San Jose scale is scarcely 2^{mm} in diameter. The adult female scale is irregularly circular in outline, quite flat, and of a pale grayish or dirty-white color. The exuvial spot is reddish or orange and situated one side of the center. The scale often appears to be less closely attached to the bark than with the other species of this genus. The male scale is elliptical and much smaller than the female. The adult female scale hibernates, and deposits eggs in early spring. The males from them issue early in June. Eggs are deposited again in June, so that there appears to be two or possibly three broods in the South. This species is not abundant, but liable to be found on almost any orchard tree.

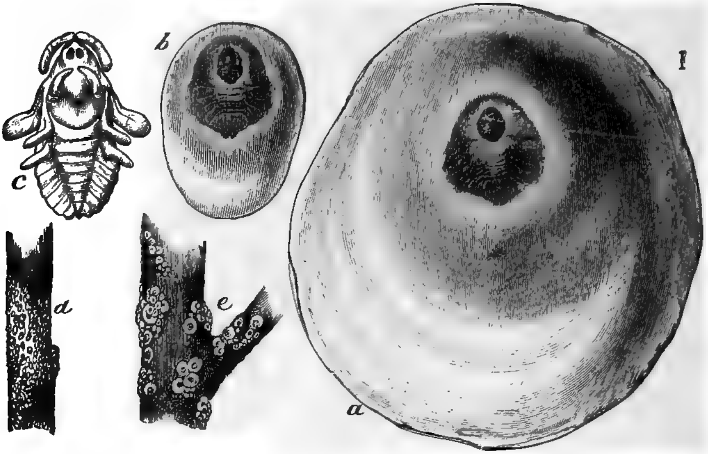

FIG. 9.—*Aspidiotus juglans-regiæ:* *a*, female; *b*, male; *c*, pupa; *d*, *e*, infested twigs. (Howard.)

THE GREEDY SCALE.

(*Aspidiotus rapax* Comstock—fig. 10.)

This is quite a large species, readily distinguished from the others we have treated by its very convex scale and uniform drab or yellowish-brown color, except for the dark brown exuvium which often shows near the center. The adult female scale is less circular than most of the other species, and does not always show the exuvial spot, which is at one side and covered with a film of secretion. The male scale is much smaller, and elliptical in outline. The young are nearly circular, with a central nipple often surrounded by a pale gray ring. This scale is very abundant in California and has spread somewhat eastward, especially in the South. It attacks various orchard trees, but more commonly the orange. It is a scale that is liable to be found more commonly in the future, and orchardists should be on the lookout for it. The greedy scale, in California, winters in all stages.

THE GRAPE SCALE.

(*Aspidiotus uvæ* Comstock.)

This is a more or less elliptical scale, with the exuvium rather nearer one end. It has a yellowish or pale brownish color, with a whitish center near the exuvium, the latter of a pale yellow. The scales are often found in a longitudinal row, and rarely infest both sides of the same branch. It winters in the egg stage. The young hatch in May; the males issue in the summer. There is but one brood a year. It is practically confined to the grape, but has been found on a few other plants, and may spread to fruit trees.

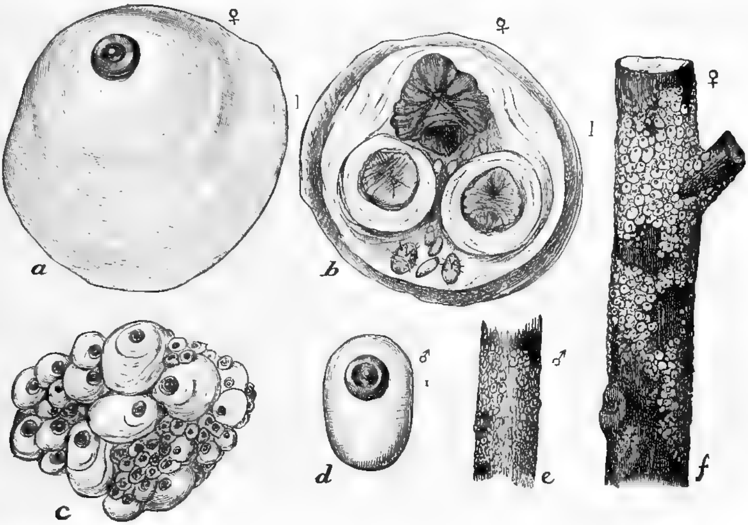

FIG. 10.—*Aspidiotus rapax.* Scales on twigs, and enlarged. (Howard.)

THE PEACH SCALE.

(*Diaspis pentagona* Targ. Tozz.—fig. 11.)

The peach scale, sometimes known as the "whitewash scale," is of a grayish white color, rather flat and irregularly circular or slightly ovate in outline, never as elongate as the scurfy bark-louse. The exuvium is often a little way from the margin, and is yellowish or

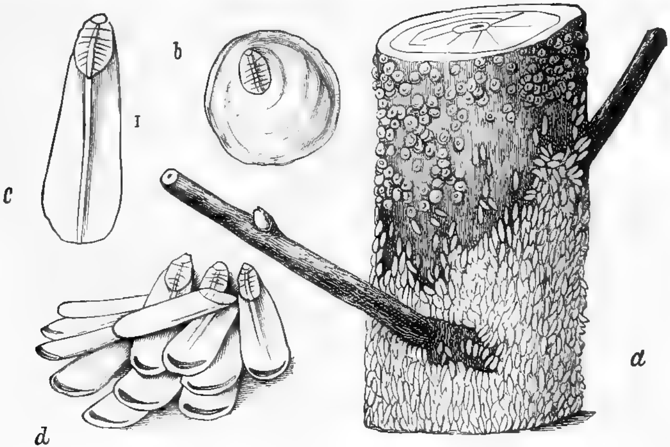

FIG. 11.—*Diaspis pentagona: a*, infested branch; *b*, female; *c*, male; *d*, group of males. (Howard.)

orange in color. Its pale color and elongate exuvium will readily separate it from all other scales on orchard trees. The insect passes the winter with the mature females and the male scales. The males hatch in early spring. The eggs are laid early in May, and the larvæ hatch in about ten days. The males again commence to issue by the middle of June, and the females begin egg-laying by the end of June. The second generation is full grown by the middle of August, and these in time soon begin to lay eggs for the brood that will winter as mature females and undeveloped males.

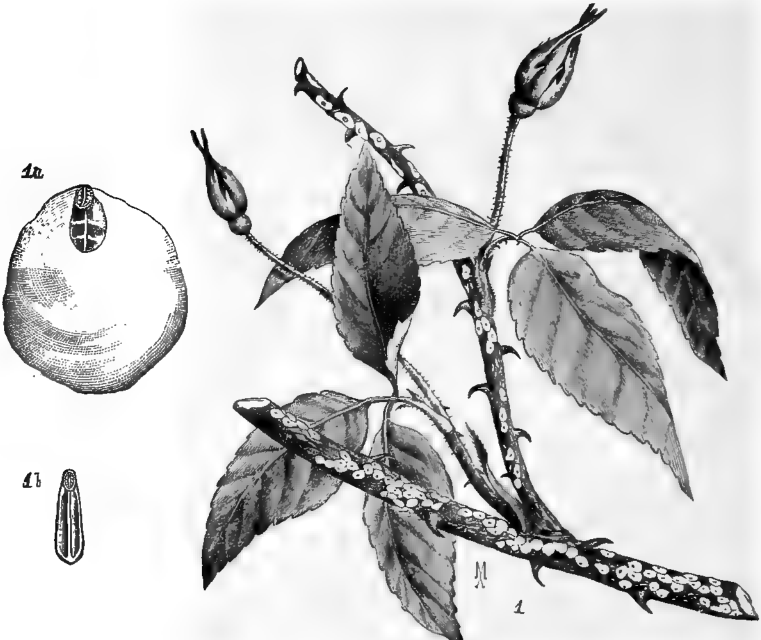

FIG. 12.—*Aulacaspis rosæ; 1*, infested branch; *1a*, female; *1b*, male. (Comstock.)

The male scale (fig. 11, *c*, *d*) is elongate, about three times as long as broad, slightly wider behind than in front, with a median keel, and snow white in color. The male scales appear to be most numerous on the lower parts of the branches and near the base of the trunk and often so matted as to make the trunk or lower branches absolutely snow white. The peach scale is becoming common in many of the Southern States and as far north as Pennsylvania. It infests plum, cherry, and peach, and less commonly other plants.

THE ROSE SCALE.

(*Aulacaspis rosæ* Sandberg—fig. 12.)

This species is similar to the peach scale, and, indeed, the easiest way to distinguish between them is by their host plants. The peach scale does not affect the host plants of the rose scale, which are roses, raspberry, and blackberry. The scale covering is much more thin and delicate and the exuvium is usually of a paler or duller yellow than in the case of the peach scale. The keel or ridge of the male is more distinct. The life history of this species does not appear to be well known in this country. It winters, as a rule, in the egg as far north as New Jersey; but mature females and immature females and males may be found in winter. In the early spring one often finds the female scales surrounded by a radiate row of male scales. It is probable that there is more than one brood in a year, at least in the South.

FAMILY APHIDÆ (PLANT-LICE).

The plant-lice are small, sluggish insects found on the under surface of leaves or on the bark and roots. Most of the individuals have no wings, but at times one finds some specimens with delicate transparent wings laid roof-like over the body. They all have distinct legs, a pair of moderately long antennæ, and usually quite prominent eyes. They occur in colonies, and by their numbers often do a considerable amount of damage. The eggs are found on trees in winter situated near the base of twigs and buds. (See fig. 13.) They are minute, oval, or elliptical shining black objects. During the warm part of the year the females produce living young, so that one individual may, in a few months, be the parent of a large colony. Many of the species secrete a sweetish liquid from two pre-apical tubes or cornicles. This liquid is known as honey-dew, and attracts other insects, especially ants.

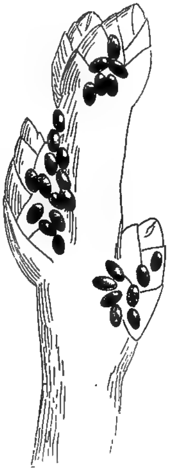

FIG. 13.—Eggs of a plant-louse on twig. (Original.)

TABLE OF PLANT-LICE.

A. Plant-lice on the bark or roots:	
With a whitish, woolly, or cottony covering	*Schizoneura lanigera.*
Without such covering	*Aphis persicæ-niger.*
B. Plant-lice on the leaves:	
With bluish-white mealy powder; on plum	*Hyalopterus pruni.*
Dark brown; on cherry	*Myzus cerasi.*
Green, or faintly reddish; on apple	*Aphis mali* and *A. sorbi.*

THE WOOLLY APPLE APHIS.

(*Schizoneura lanigera* Hausmann—figs. 14 and 15.)

One often notices on the trunk or larger branches of the apple small, bluish-white, flocculent patches of a woolly substance, which indicate the presence of this insect. This cottony substance is a wax-like excretion clinging to the posterior parts of a small, reddish-brown wingless aphis. It is not, however, this form on the trunks that causes injury. This aerial form is but the indication that there are other specimens, under the ground and feeding on the roots of the tree. It is the latter form that seriously affects the vitality of the tree. Upon the trunk the lice often cause a roughening of the bark, especially on the new growth around scars made by pruning. On the roots the lice cause hard and large knots, which eventually produce a "club-footed" condition of the roots. Such trees usually show their weakness by the fewer and duller colored leaves.

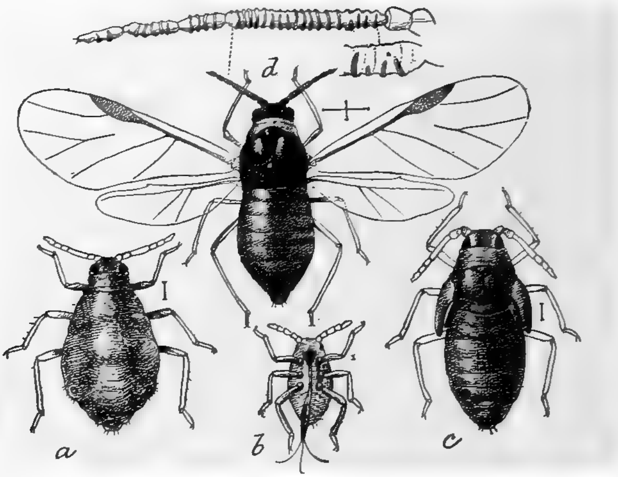

FIG. 14.—*Schizoneura lanigera; a,* agamic female; *b,* larva; *c,* pupa; *d,* winged female. (Marlatt.)

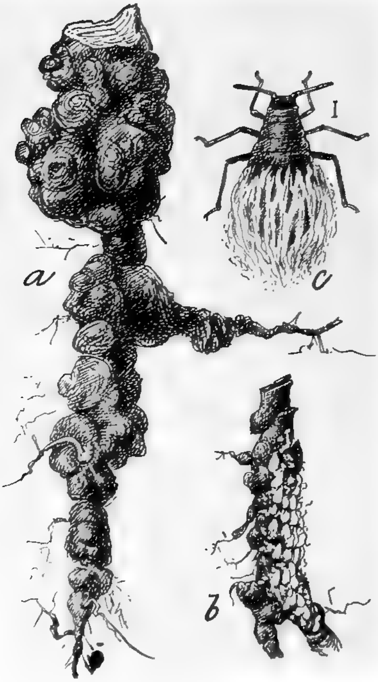

FIG. 15.—*Schizoneura lanigera; a, b,* work on roots; *c,* a louse. (Marlatt.)

The woolly aphis is practically confined to the apple, but there are a few varieties, such as the Northern Spy, that appear to be immune against its attacks. The lice commonly found on the trunk and roots in summer are the wingless, agamic females. They give birth to living young, and continue to do so, possibly for several years. In spring some of the root-lice will crawl up the trunk and continue to breed there till fall. The colonies of lice on the trunk give rise to winged and migratory females. These, when they locate, give birth to wingless male and female lice, and each female deposits a single winter egg in a crevice of the bark. This egg will, in the spring, hatch into a female which will start a new colony of wingless lice on the trunk. Some of these will, in the summer, crawl down upon the roots and continue to breed there. In the north the colonies on the trunk are apt to be killed out by the severe cold weather, but in warmer latitudes many of them live through the winter, particularly if they are protected by a piece of bark.

THE BLACK PEACH APHIS.

(*Aphis persicæ-niger* E. F. Smith—fig. 16.)

This insect, like the woolly apple aphis, does its great injury underground. Its ravages on the roots of peach give a sickly appearance to the foliage of the affected tree, the leaves often being light green or yellowish in color, and their edges somewhat rolled. The wingless lice on the roots are of a dark-brown color. They breed there continuously without producing males or eggs. Early in the spring some of the root-lice crawl up the trunk of the tree and locate on the young twigs. Here the winged form develops and migrates to other trees to found other colonies. The winged insect is of a shining black or very dark brown color, the tibiæ of the legs being mostly yellowish.

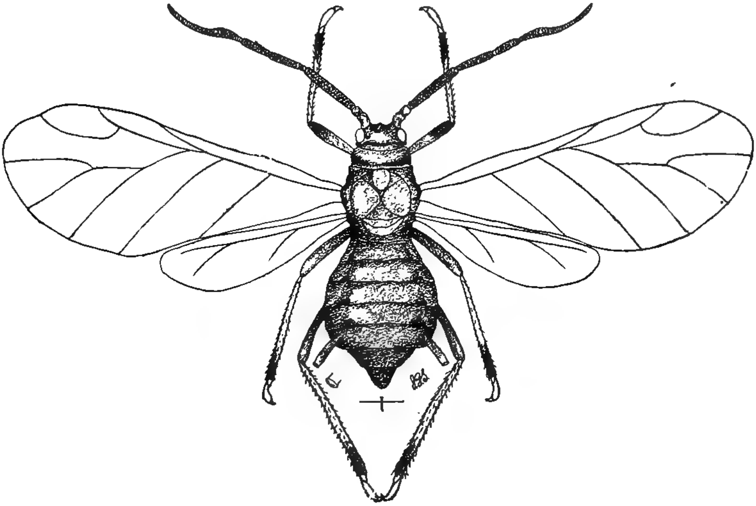

FIG. 16.—*Aphis persicæ-niger;* winged specimen. (J. B. Smith.)

Toward midsummer many of the lice on the twigs crawl down into the ground and locate upon the roots.

APPLE PLANT-LICE.

The foliage of apple trees, particularly of young trees, often appears curled, and sometimes discolored. This curling is produced by colonies of plant-lice. These lice secrete a sticky liquid known as honey-dew, which falls on the leaves below. A black fungus grows upon the leaves covered by the honey-dew, and this checks their growth. There are several of these plant-lice that attack the leaves of apple; two of them are greenish in color, another has a reddish tinge.

The commoner of the two green species is known as *Aphis mali* Fitch. (probably *Aphis annuæ* Oest). Its life history is about as follows: The eggs are laid on the tree in the fall, partly hidden in crevices of the bark; the young hatch from these eggs in early spring, and grow into wingless and sexless lice, known as "stem-mothers," which produce living young; these young become winged, and, in the early summer, migrate to grasses, where they increase during the summer. In the fall they develop a set of winged, sexless lice, which migrate back to the apple and give birth to sexed individuals; these pair, and the female lays her eggs.

The other green species is *Aphis mali* Koch. It passes its entire life history upon the apple. The eggs are laid in the late fall. They are black, and occur generally on the trunk and branches. In early spring the young hatch from these and grow into stem-mothers. These produce living young for a number of generations. Many of these of the first two generations become winged, fly to other apple trees, and there start colonies. In October sexed specimens are produced, and the female lays the eggs that are destined to pass the winter.

The other apple plant-louse is *A. sorbi* Kalt. It is distinctly tinged with red, and the wingless forms have a whitish powdering on the body. This species has a life history similar to that of *Aphis mali* Fitch., but it is not known what plants serve as its summer hosts.

THE PLUM PLANT-LOUSE.

(*Hyalopterus pruni* Fabr.)

This insect winters in the egg state. The young on hatching in spring go to the under surface of the leaf and there multiply rapidly. Their bodies are covered by a bluish-white mealy powder. Winged specimens are occasionally developed which migrate to other trees. They feed on the plum all summer, but some specimens are said to migrate to grass in early summer. In the fall the winter egg is attached to a plum twig, usually at the base of a bud. At times they do considerable damage to young plum stock.

THE CHERRY APHIS.

(*Myzus cerasi* Fabr.)

This aphis often causes the leaves of the cherry to become crumpled and rolled, and on young trees sometimes does serious damage. The winged and wingless insects are both of a dark brown color, and look much like the black peach aphis. The eggs are laid in the fall on the branches at the base of buds and in crevices of the bark. The young hatch from them in the spring when the buds begin to swell, crawl out upon the buds and growing leaves, and develop into stem-mothers, which give birth to living young. This is kept up all summer until the fall, when the sexes appear and the female deposits her eggs. A number of winged migrants are developed in the spring generations, which serve to spread the species. The insects usually become very abundant by June, but in midsummer they are not as common.

FAMILY PSYLLIDÆ.

THE PEAR-TREE PSYLLA.

(*Psylla pyricola* Forster—fig. 17.)

This insect is closely related to the plant-lice, but readily known by its longer antennæ and its ability to hop. Its color is reddish, with some black markings, and with clear wings laid roof-like over the body. When disturbed, it hops and flies away.

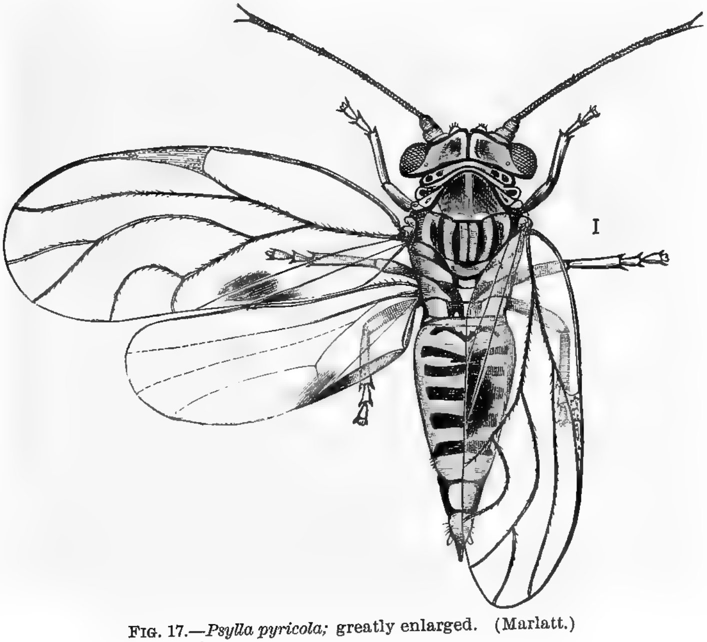

FIG. 17.—*Psylla pyricola;* greatly enlarged. (Marlatt.)

The insect is widely distributed in the East, but usually is not abundant enough to seriously injure the tree. When they become excessively abundant they cause the leaves and fruit to dry and fall. The adult insect hibernates in crevices of the bark. These overwintering specimens are brownish-black in color, with bronzy eyes. They emerge from their hiding places in the early spring, mate, and the female begins to lay eggs before the leaves are out. The eggs are placed singly or in groups in crevices of the bark of the twigs or in old leaf scars, and, when the leaves have unfolded, upon the leaves themselves. The larvæ hatch in about two weeks and begin to suck the juices from the leaves and petioles. They at once commence to excrete honey-dew, and when the insects are extremely numerous the amount of liquid secreted is enormous and fairly rains from the tree. A black fungus grows on the honey-infested leaves and tree, so that the whole soon has a smoked appearance. In about thirty days the larva becomes adult. Development continues all through the summer, and there may be as many a five broods if the season be long enough. It is only known to attack the pear.

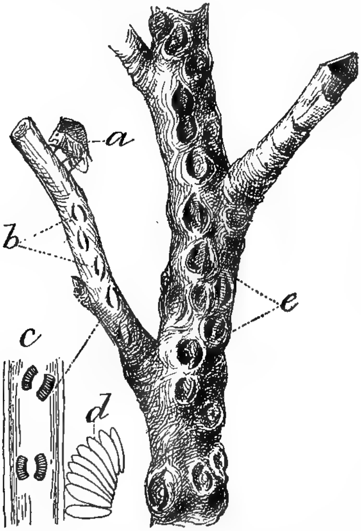

FIG. 18.—*Ceresa bubalis: a*, insect; *b*, recent punctures; *c*, eggs; *e*, old scars. (Marlatt.)

FAMILY MEMBRACIDÆ.

THE BUFFALO TREE-HOPPER.

(*Ceresa bubalus* Say—fig. 18.)

Upon young fruit trees, particularly the apple, one sometimes sees a series of oval or elliptical scars that disfigure and weaken the branches and render them liable to other insect attack. These scars are the results of the work of a curious insect, the buffalo tree-hopper. It is a grass-green, triangular insect that hops and flies away when disturbed. The pronotum of the thorax is enlarged, as with others of this family, to cover the head and most of the abdomen. The anterior corners of the pronotum project laterally into acute angles. In August and September the adult insects may be found on the trees engaged in oviposition. The female cuts the bark with her ovipositor in two nearly opposite curved slits, so that the bark between is cut loose. Beneath each slit she deposits a series of from 6 to 12 eggs. These eggs hatch in the spring. The dead piece of bark falls out and leaves the elliptical scar, which enlarges with the subsequent growth of the twigs and becomes an inviting point for the attack of other insects. There is but one brood each year.

LEPIDOPTERA (BUTTERFLIES AND MOTHS).

The caterpillars and cocoons of these insects are known to all. The caterpillars differ from the grubs of beetles in that they have on the under side two rows of prolegs—fleshy, wart-like structures that serve to support the posterior part of the body. The injuries caused by these insects are made by the caterpillar. These have biting mouth-parts that nip out tiny pieces of the leaf or wood, which is then chewed and swallowed. The more injurious forms that are liable to be transported on nursery stock may be arranged as follows:

1. Feeding within the trunk.................................Peach-tree borer.
Feeding within the twigs or leaf-shoots......................Peach twig-borer.
Feeding upon the leaves.. 2.
2. The insect covered by a case.........Bagworm, leaf-crumpler, pistol-case bearer, cigar-case bearer.
The insect not covered by a case....................................... 3.
3. Making tents or nests..........Apple-tree tent caterpillar, fall webworm, brown-tail moth, leaf-crumpler, and bud moth.
Without tents.. 4.
4. Hairy caterpillars ....Tussock moth, gipsy moth.
Bare caterpillars ....Cankerworms.

THE APPLE-TREE TENT CATERPILLAR.

(*Clisiocampa americana* Harr—fig. 19.)

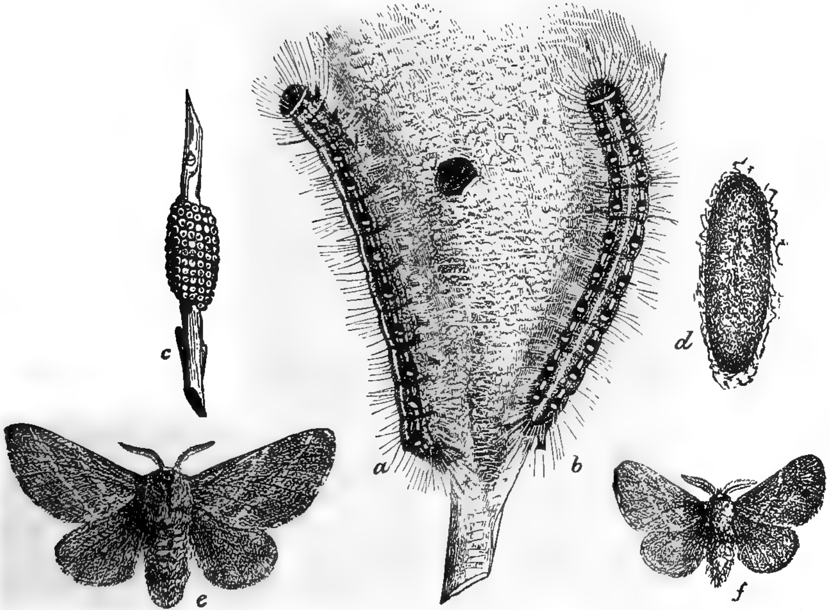

FIG. 19.—*Clisiocampa americana: a, b,* caterpillars; *c,* egg-mass, *d,* pupa, *e,* female; *f,* male. (Riley.)

The webs or tents of this caterpillar are frequently found on orchard and nursery trees in May and June. The caterpillars use this tent as a common home, where they retire at night and remain during cloudy days. Each clear morning, at about 8 o'clock, they go out along the branches to the leaves for feeding. The amount of damage done will depend a great deal upon the number of tents upon the tree. The eggs are laid in masses of 200 or 300 arranged in a broad belt around the twig. (See fig. 19, *c.*) Each end of this belt tapers off to the twig, which character serves to distinguish it from similar egg-clusters of certain other moths. Each mass is covered with a glistening substance that protects it from the rain. The young caterpillars hatch during the latter part of April or early in May, at about the time when the leaves are expanding. They immediately begin to feed on the leaves near by and to unite them into their tent, which is enlarged as the caterpillars grow. The full-grown larva is nearly 2 inches long, hairy and black, with a white stripe along the back. On each side of this is a row of short, yellow streaks; there are also pale lines on the sides of the body. The under side is nearly black. When ready to pupate the caterpillar seeks some protected spot and there spins its yellowish cocoon, and soon changes to a brown chrysalis. The moth, which is brown, with oblique white bands across the forewings, emerges in a week or so and deposits her egg-mass and dies. There is but one brood a year.

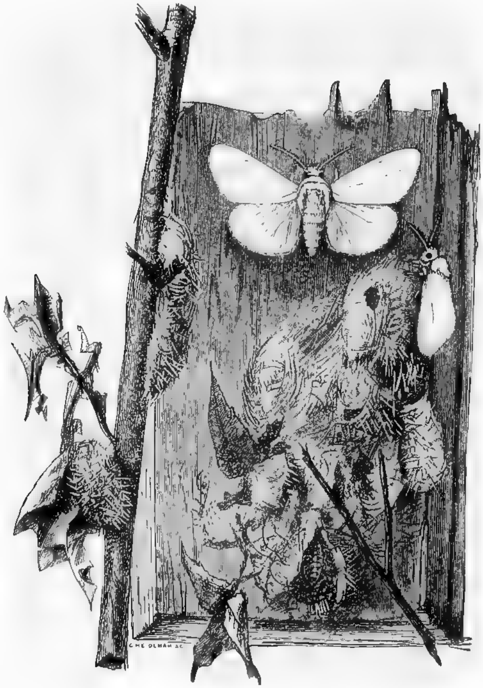

FIG. 20.—*Hyphantria cunea:* moths and cocoons. (Howard).

THE FALL WEBWORM.

(*Hyphantria cunea* Dru.—fig. 20.)

During the summer and early fall webs or tents similar to those of the apple-tree tent caterpillar are often seen among the terminal branches of fruit trees. These are the work of the fall webworm. The eggs of this moth, 300 to 500 in number, are laid in patches on either side of the leaves in June. The larvæ issue from June to August, and at once begin their web. They eat only the upper surface of the leaf, leaving the veins and the under surface untouched. The young caterpillar is pale yellowish, with dark spots along the sides and covered with scattered hairs. The full-grown caterpillar is velvety black above, the sides have two yellow stripes, and between them are many blackish patches and dots. The yellowish or brownish hairs are mostly in tufts which arise from tubercles or warts. Some specimens are quite pale; others very dark. In September or October the caterpillar is ready to pupate, and descends to the main branches or trunk of the tree. Here it makes a delicate cocoon, within which it changes to a chrysalis. The insect passes the winter in this stage, and the moth emerges the following spring. The latter has white, sometimes spotted wings, and expands about an inch and a half. There is but one brood each year in the North, but from New York city south there are two broods, the caterpillars of the second making their appearance in August.

THE BROWN-TAIL MOTH.

(*Euproctis chrysorrhea* Linn.—fig. 21.)

This insect, at present confined to certain parts of eastern Massachusetts, is such a dangerous pest that all interested in nursery trade should be able to recognize it. During winter their small but very compact webs or nests attached to the terminal twigs are very prominent objects and will aid in distinguishing the species. In midsummer the eggs may be found in patches of two or three hundred attached to the under side of a leaf near the tip of a branch. The egg mass is covered by a dense layer of brown hairs from the tip of the abdomen of the female. The young hatch in August and eat the surface of the leaf. As soon as it is devoured they draw another leaf to it, until

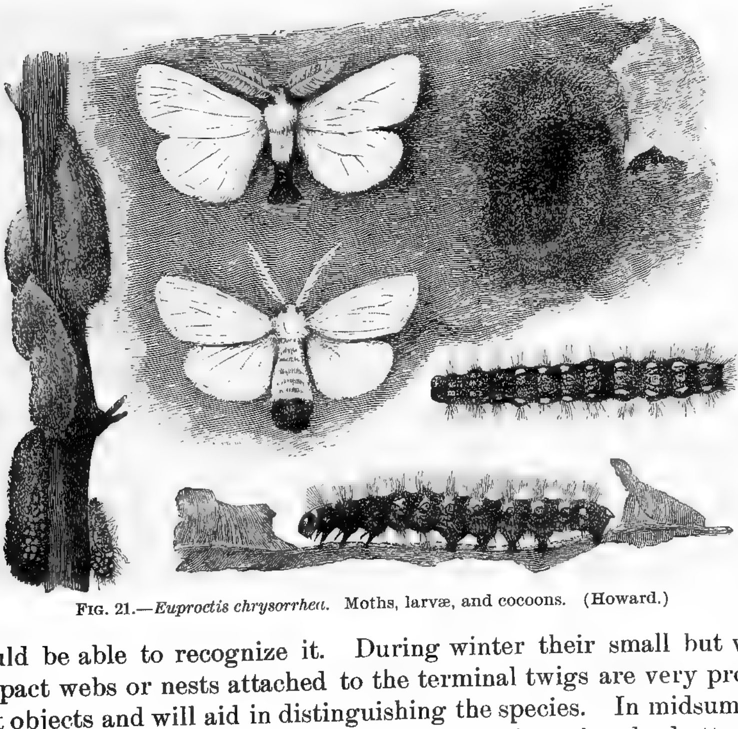

FIG. 21.—*Euproctis chrysorrhea.* Moths, larvæ, and cocoons. (Howard.)

in the fall they have quite a tent. On the approach of winter they strengthen their tent and use it to shelter them during the winter. In spring they come out, eat the unfolding buds and tender leaves, and thus do great damage. The full-grown caterpillar is about 1½ inches long, dark brown, mottled, and spotted with orange, and clothed with reddish-brown hairs and two rows of dense tufts of white hair along the upper side of the body. By the middle of June the caterpillars are ready to pupate, and each makes a cocoon attached to a terminal branch, or sometimes elsewhere on the tree, or even on some other object. These cocoons are often close to each other, so as to form quite a mass. The moths emerge in a few weeks. They have white wings, and the females a brown tip to the abdomen. There is but one brood each year.

THE LEAF-CRUMPLER.

(*Mineola indiginella* Zell.)

The presence of this insect is easily recognized in winter by the clusters of brown, shriveled, and partly eaten leaves fastened together and to the twigs by silken threads. Within each cluster of leaves is a curved tube, usually sinuate at the small end, and within this tube is the small, brownish caterpillar of this moth. This caterpillar is but half grown. In early spring the larva cuts loose from its fastenings, crawls with its case out upon the branches, and attacks the developing buds and young leaves, thus causing a great deal of injury. The caterpillar becomes full fed by the middle of May, and is then of a greenish color. It pupates in the larval nest, and the moths issue in June or early July. The eggs are deposited in July, singly on the leaves. The young larva, upon hatching, starts to make a little case for itself, which it enlarges when necessary. They feed on all fruit trees, but are partial to apple, and there is but one brood annually.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* S. & A.—fig, 22.)

The caterpillar of this moth, which does great damage to shade trees in cities, sometimes attacks apple and other fruit trees. The adult insect is a light-grayish moth, the female wingless, the male with ash-gray wings, expanding about 1¼ inches, and the antennæ are feathered. The eggs, 300 to 500 in number, are laid by the wingless female in the fall within a frothy substance, which on drying becomes hard and brittle. The whole is a very prominent whitish mass, often situated partly or wholly upon the old cocoon. In May the young larvæ hatch and begin eating the foliage. The larvæ are full-grown in July, and spin their slight silken cocoons, attached to any convenient spot. The full-grown caterpillar is a very handsome insect, about 1½ inches in length, yellowish, with three blackish stripes along the body, and a bright-red head. It is clothed with long, scattered hairs, four white

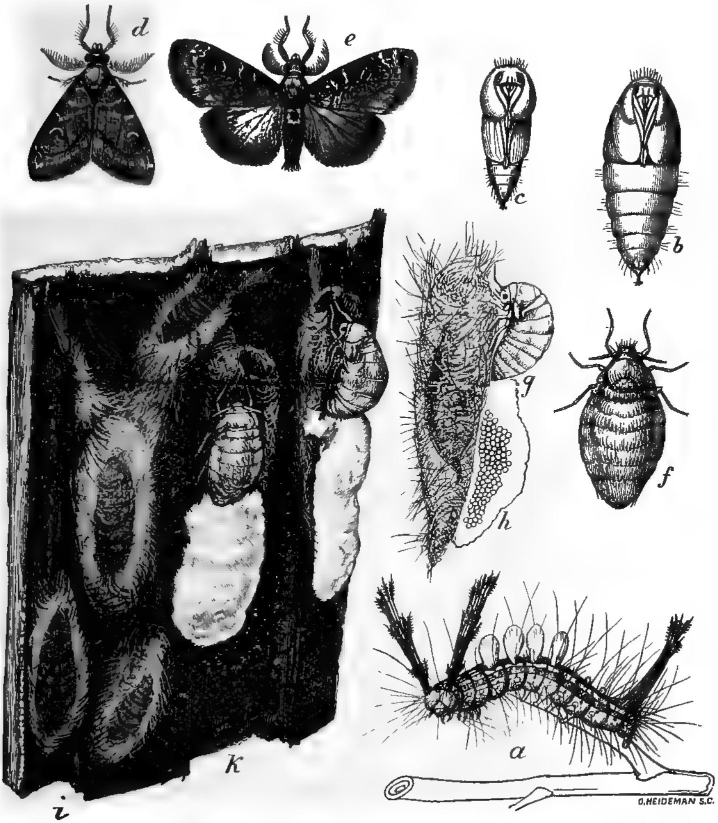

FIG. 22.—*Orgyia leucostigma.* Various stages; eggs at *h* and *k*. (Howard.)

tufts on the anterior part of the body, and three long black plumes, two in front and one at the tip of the body. In the North there is but one brood a year, but from New York city south there are usually two broods, the caterpillars of the second appearing in early August.

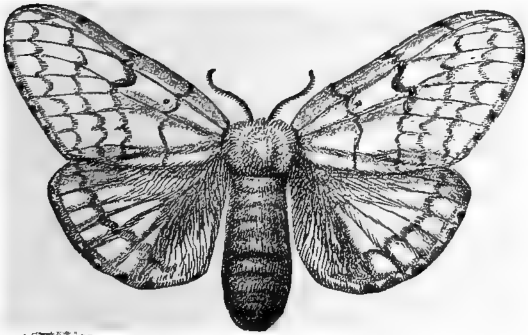

FIG. 23.—*Porthetria dispar:* female moth. (Howard.)

THE GIPSY MOTH.

(*Porthetria dispar* Linn—figs. 23, 24, and 25.)

Although practically confined to certain parts of Massachusetts, this insect is quite liable to spread, and all interested in orchards and nurseries should be able to recognize this caterpillar.

The eggs to the number of 400 to 500 are deposited in clusters attached to trees, fences, etc. Each cluster is covered with yellow hairs from the body of the female, which causes the mass to resemble a piece of sponge. The caterpillars hatch from April to June, and feed voraciously on the leaves, mostly at night. The full-grown caterpillar is about 2 inches long, of a grayish, mottled appearance, with the tubercles on the anterior part of the body blue, and those on the hinder part of the body red, all giving rise to long yellow and black hairs. When the caterpillars are about half grown they begin to crawl down the tree to the ground in early morning, and ascend again for feeding in the evening. By July they are ready to pupate in a thin cocoon fastened to the trunk of the tree, to a fence, or other convenient object. The pupal period is about ten days, and the moths issue in August. The female moth has whitish wings with several black spots, notably around the outer margin. The male is brownish, with darker undulate lines and spots. The gipsy moth attacks almost every sort of tree, and there is but one brood a year.

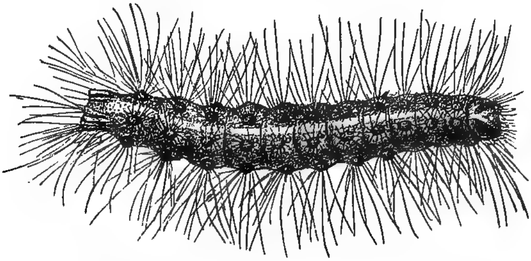

FIG. 24.—*Porthetria dispar.* Larva. (Howard.)

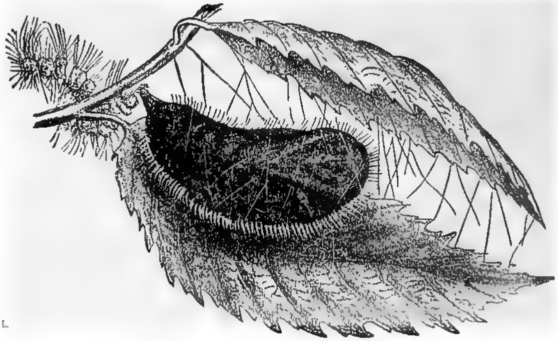

FIG. 25.—*Porthetria dispar.* Chrysalis. (Howard.)

CANKERWORMS.

(Figs. 26, 27, 28, and 29.)

These slender, bare caterpillars appear on apple and other fruit trees in early spring and eat holes in the leaves. As they crawl they loop up the body, and are thus called "measuring worms" or "inch worms." There are two species of the cankerworms, their habits, however, being similar. The eggs are laid in clusters on the tree in the fall and early winter, with the fall species (*Alsophila pometaria* Harr.); in March or April with the spring species (*Paleacrita vernata* Peck). The eggs of the former are flattened on top; those of the latter are rounded. The larvæ hatch in early spring and at once feed on the leaves. When full grown they descend to the ground and pupate therein, the moths issuing in late fall or very early spring. The females are wingless, and obliged to crawl up the tree to deposit eggs. The males have large, thin, gray wings. There is but one brood each year.

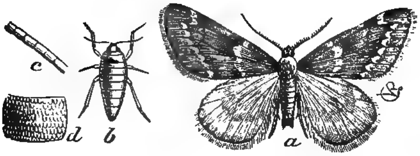

FIG. 26.—*Alsophila pometaria: a*, male; *b*, female. *c*, *d*, details. (Riley.)

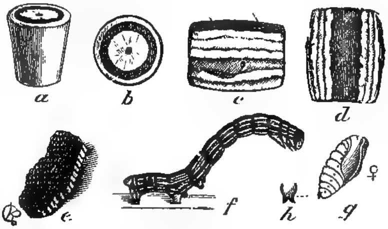

FIG. 27.—*Alsophila pometaria: a*, *b*, *c*, eggs; *f*, larva; *e*, *d*, segments of same; *g*, pupa. (Riley.)

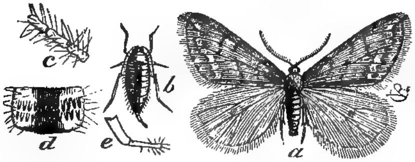

FIG. 28.—*Paleacrita vernata: a*, male; *b*, female, *c*, *d*, *e*, details. (Riley.)

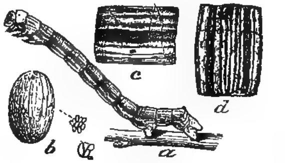

FIG. 29.—*Paleacrita vernata: a*, caterpillar; *b*, egg; *c*, *d*, segment of caterpillar. (Riley.)

THE PEACH-TREE BORER.

(*Sanninoidea exitiosa* Say—fig. 30.)

This destructive insect is readily discerned by the presence of a gummy exudation mixed with frass and excrement at or near the base of the tree. The parent moth lays the eggs singly (from May to July, according to latitude) on the bark of the tree, usually near the base. The young larva burrows into the bark and mines between it and the sapwood during the summer and fall. It is quiescent during the winter, but resumes feeding in the early spring, reaching full growth by May or June. The caterpillar is then a little over 1 inch in length, soft, and pale yellowish in color, with a shining, dark-brown head. It transforms to a chrysalis within an elongate cocoon just beneath or sometimes outside of the bark. The moths emerge in May or June. The female has dark-blue fore-wings; the male has clear ones. It primarily attacks peach, but sometimes cherry and plum. There is but one brood each year.

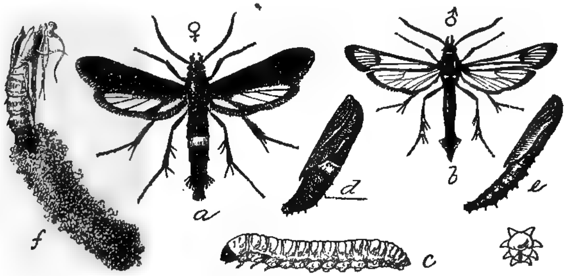

FIG. 30.—*Sanninoidea exitiosa:* a, female; b, male; c, larva; d, e, female and male pupæ; f, cocoon. (Marlatt.)

THE PEACH TWIG-BORER.

(*Anarsia lineatella* Zell.—fig 31.)

The presence of this insect in the winter is quite readily known by bits of frass attached to the bark, often at the crotches of branches or twigs. Each bit of frass covers the entrance to a small burrow lined with silk, within which the young larva of this insect passes the winter. It is now of a yellowish color, with the head and thoracic segments, as well as the last segment, almost black. Early in spring, when the leaves are coming out, the larvæ abandon their burrows and attack the tender leaf shoots, boring into them from a point a little below the apex, and when one shoot commences to dry the larva leaves it and attacks another. In about two weeks the larva is full grown, and pupates in a slight open cocoon attached to the bark or among the shriveled leaves. The tiny, grayish moth issues in May. Two broods follow this, the larvæ boring in the young twigs

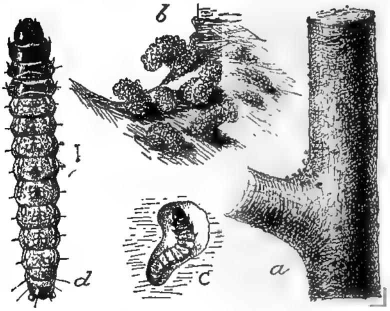

FIG. 31.—*Anarsia lineatella:* a, infested twig; b, same enlarged; c, larva in case, d, larva enlarged. (Marlatt.)

or sometimes in the immature fruit. The larva from the second brood makes the little burrows in the bark in which the insect passes the winter. The peach twig-borer feeds on all stone fruits.

THE BAGWORM.

(*Thyridopteryx ephemeræformis* Haw.—figs. 32 and 33.)

The winter cases or bags of this insect, 1½ to 2 inches long, are often seen hanging from the branches of shade trees, particularly arborvitæ, locust, and basswood, but are not so common on fruit trees. The adult insect is a moth; the female wingless; the male with four transparent wings and a black body. The female never leaves her case alive, but in the fall deposits her eggs therein, drops out and dies,

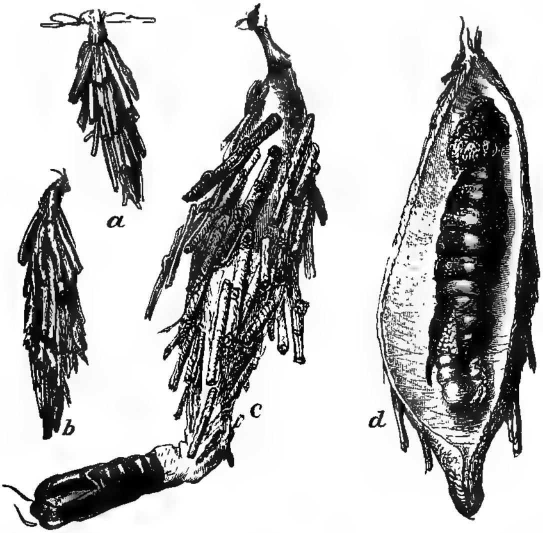

FIG. 32.—*Thyridopteryx ephemeræformis.* Cases; *d*, one cut open. (Howard.)

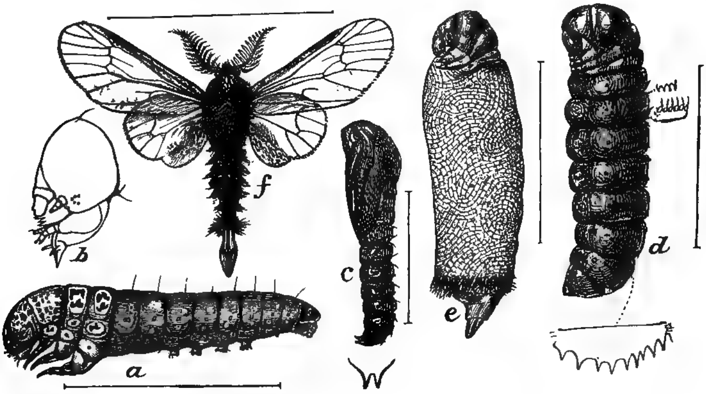

FIG. 33.—*Thyridopteryx ephemeræformis: a*, larva; *b*, head of same; *c*, male pupa; *d*, female pupa, *e*, adult female; *f*, adult male—all enlarged. (Howard.)

the case remaining attached to the tree all winter. In May the young hatch, and at once start to make little cases for themselves, which they enlarge as they grow. When ready to pupate, the caterpillar fastens its case to a twig and transforms to the chrysalis. The male moth appears in August. There is but one brood a year.

OTHER CATERPILLARS.

On the apple tree in winter one may find several other caterpillars in various stages of development. One of them, the pistol-case bearer (*Coleophora malivorella* Riley), is a small larva with a dark head. It carries with it a case the tip of which is curved over, the whole about one-eighth inch long. It feeds on the buds and leaves in spring. In the fall it fastens itself securely to the twig, and thus passes the winter in an immature condition.

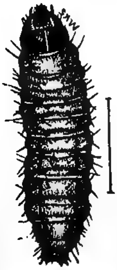

FIG. 34.—Larva of bud-moth. (Slingerland.)

Another is the cigar-case bearer (*Coleophora fletcherella* Fern.). It has a life history similar to the preceding, but its case is straight, not curved. Both feed on the pear and quince.

Small, elongate, white, ribbed cocoons, nearly one-fourth of an inch long, often in clusters, are sometimes seen on apple bark in winter. They indicate the presence of the apple-leaf bucculatrix (*B. pomifoliella* Clem.). In spring the tiny, delicate moths issue from the cases. The larvæ mine the leaves. There are two broods annually.

Small, inconspicuous cases, covered with particles of dirt and bark, are, at times, found on the bark of the apple and pear. These contain the half-grown larva of the bud-moth (*Tmetocera ocellana* Schif., figs. 34 and 35). In spring the larva feeds on the buds and young leaves, webbing the leaves in a bunch or nest. They pupate within this nest. The moth issues in July, and is a grayish insect with a creamy white patch on each fore-wing. During the summer the young larvæ partially skeletonize the leaves, feeding beneath a thin silken web. As winter approaches they migrate to the twigs and form their hibernating cases. There is but one brood a year.

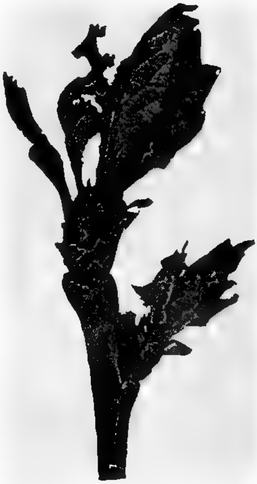

FIG. 35.—Work of bud-moth larvæ in opening twigs. (Slingerland.)

COLEOPTERA (BEETLES, WEEVILS).

Beetles are easily known by the hard, coriaceous fore-wings that cover and protect the back of the abdomen. Both in the larval and the mature conditions they have biting mouth-parts, and injury is sometimes done by both the grub and the beetle. The grubs, to reach the adult condition, pass through a complete change or metamorphosis, like caterpillars, but do not spin a silken cocoon. The grubs do not have the prolegs that are found in caterpillars. The forms to be noticed below may be arranged as follows:

1.	Boring in the twigs	Apple twig-borer.
	Boring in the trunk or larger branches	2.
2.	Making tiny circular holes in the bark	Fruit-tree bark-beetle.
	Making a sinuate crack or depression	Sinuate pear borer.
	Discolored spots on the bark	Round-head and flat-head apple-tree borers.

THE ROUND-HEADED APPLE-TREE BORER.

(*Saperda candida* Fab.—fig. 36.)

Discolored places on the bark near the base of the trunk may indicate the presence of this borer. Sometimes the bark cracks over the burrow and allows the frass or "sawdust" to drop out, and often there is some exudation of sap. Every unnatural-looking spot near the base of the tree should be examined. The adult of this borer is a grayish, long-horned beetle with two white stripes along its back. They appear in June and July, and lay their eggs in little slits in the bark made by the beetle near the base of the trunk. The larvæ or grubs soon hatch and bore beneath the bark, feeding on the sapwood and inner bark, and making flat, shallow cavities, partially filled with frass. The grubs are nearly cylindrical, pale yellowish in color, and when full-grown about an inch long. On the approach of winter they work downward, often below the surface of the ground. In spring they begin to feed again, boring upward. In this manner they feed all summer until cold weather, when they again hibernate. In the spring they resume work, but now they bore more irregularly and further into the tree. In early fall they bore close to the surface, work back

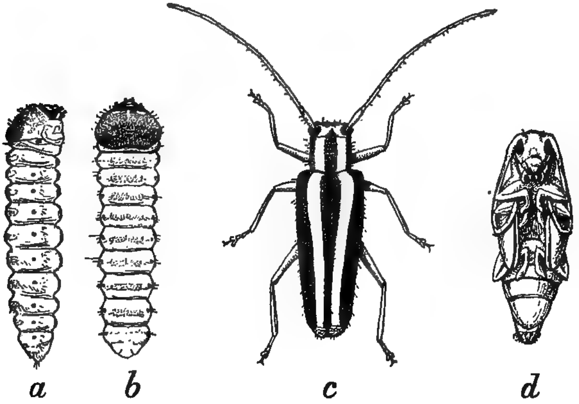

FIG. 36.—*Saperda candida*: *a*, *b*, larva; *c*, beetle; *d*, pupa, enlarged. (Chittenden.)

a little, and then pupate. Winter is passed in this condition, and in June the beetles cut *circular* holes in the bark and escape. It thus takes three years to reach maturity. This borer also infests pear and quince, but not so frequently as the apple.

THE FLAT-HEADED APPLE-TREE BORER.

(*Chrysobothris femorata* Fab.—fig. 37.)

Discolored spots like those caused by the round-headed borer may indicate the presence of this insect. They are, however, often found farther up the trunk, and even on the larger branches. The adult is a dark, metallic beetle, rather flat, and about one-half inch in length. The female deposits her eggs in crevices of the bark on the south side of the tree, usually during June and July, but sometimes later. They apparently prefer trees that are weak or dying, but also attack healthy ones. The young larva upon hatching eats through the bark and bores beneath the surface; leaving a flattened burrow filled with its frass. Sometimes, when more mature, they bore deeper into the sapwood. The full-grown larva is nearly an inch in length, pale yellowish in color, with the segment next to the head greatly enlarged and flattened. In the spring it bores out nearly through the bark, then moves back a little and pupates. In about three weeks the beetle cuts an *elliptical* hole in the bark and escapes. There is one brood each year. It attacks apple, pear, cherry, plum, and quince.

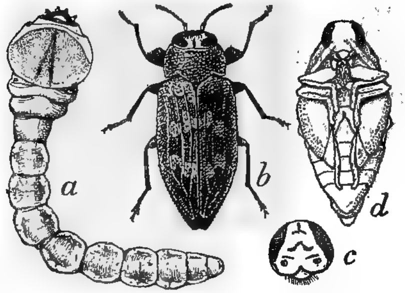

FIG. 37.—*Chrysobothris femorata:* a, larva; b, beetle; c, head of male; d, pupa, enlarged. (Chittenden.)

THE SINUATE PEAR BORER.

(*Agrilus sinuatus* Oliv.—figs. 38 and 39.)

The larva of this insect bores long, sinuate galleries beneath the bark and sapwood of pear, killing the wood and causing the bark above to crack. The elongate bronzy beetle makes its appearance in May or early June, and lays its eggs in crevices of the bark. The slender, whitish larva burrows beneath the bark, always downward. In the fall the larva becomes dormant, and is then about 1 inch long, quite flat, whitish or yellowish in color,

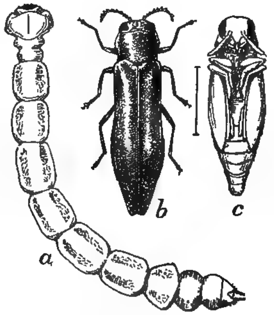

FIG. 38.—*Agrilus sinuatus:* a, larva; b, beetle; c, pupa, enlarged. (Original.)

with a brown head, and the segment next to the head much enlarged. In spring the larva resumes feeding and makes broader burrows than in the first year. In late summer or early fall, when full fed, it bores about one-fourth inch into the wood, and there forms an elongate cell parallel with the bark and connected to the outside by an exit hole. Within this cell it winters, pupates in April, and the beetle issues in May or June. It thus takes about two years to reach maturity.

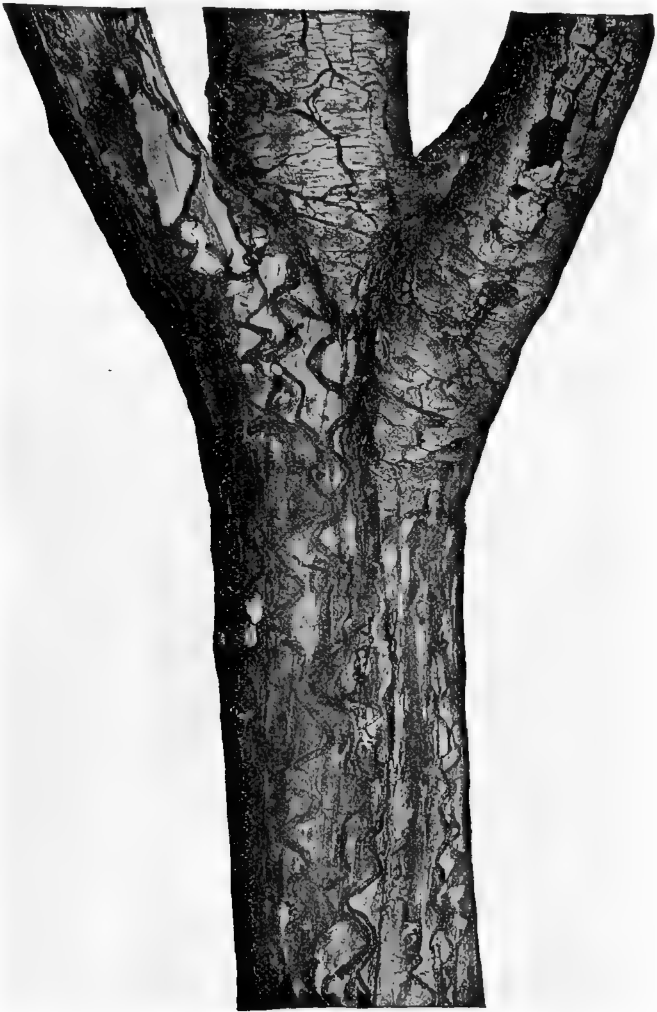

FIG. 39.—Work of *Agrilus sinuatus*, reduced. (Smith.)

THE FRUIT-TREE BARK-BEETLE.

(*Scolytus rugulosus* Ratz.—fig. 40.)

Small circular holes in the bark of fruit trees indicate this insect, known also as the "peach bark-borer" or "shot-hole borer." The adult insect, a tiny black beetle, appears in the latter part of March to the middle of May, and burrows through the bark. Between the bark and sapwood the female makes a burrow and lays her eggs along each side. The young upon hatching bore away from the parental burrow, and in about three weeks are ready to pupate at the end of the gallery.

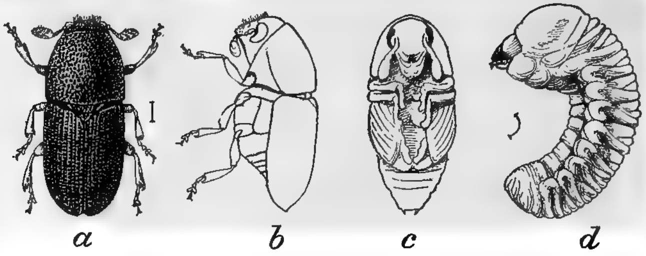

Fig. 40.—*Scolytus rugulosus: a, b,* beetle; *c,* pupa; *d,* larva; all enlarged. (Chittenden.)

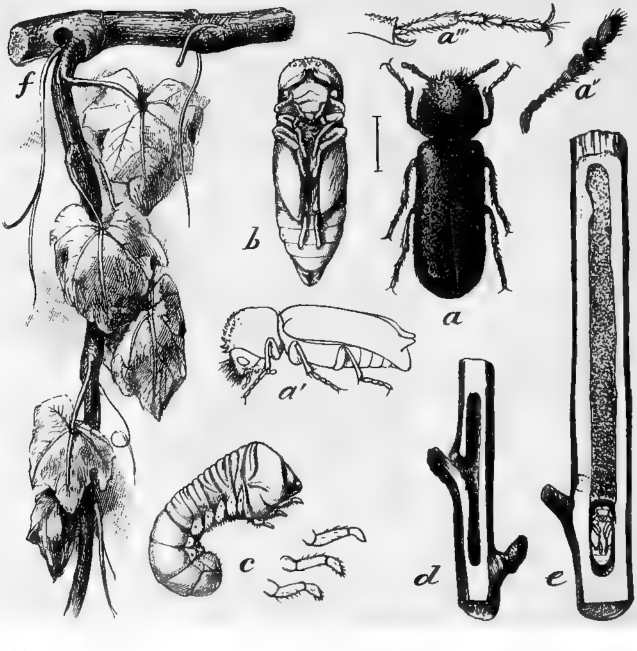

Fig. 41.—*Amphicerus bicaudatus: a,* beetle; *b,* pupa; *c,* larva; *d,* winter burrow; *e,* larval gallery; *f,* work in grape. (Marlatt.)

In about a week the beetles bore out from their burrows. The result is that the bark is loosened and sometimes the tree girdled. When they attack peach there is a great exudation of sap and a consequent weakening of the tree. There are two and probably three broods a year, but as they start at different times the broods become mixed. It attacks all kinds of fruit trees, and prefers trees that are dying, diseased, or weakened by other insects, but healthy trees are not exempt.

THE APPLE TWIG-BORER.

(*Amphicerus bicaudatus* Say—fig. 41.)

In the fall and winter the adults of this insect bore into twigs of apple and other fruits, as indicated in fig. 41, *d*. Cutting back from this hole one will find this borer in the adult state—a cylindrical brown beetle about one-third of an inch long. These holes are their hibernating quarters. In the spring the insect works in grape canes, causing the withering of new shoots, as indicated at fig. 41, *f*. In the spring the beetles emerge and insert their eggs in diseased or dying twigs of grape, maple, or other plants; the larva bores through the center of the twig until fall, when it pupates. The beetle issues in late fall, and there is but one brood a year. It attacks chiefly apple, pear, peach, plum, and grape.

ACARINA (MITES).

The mites are not insects, although related to them. They are recognized by lacking the distinction between the head and thorax and by the absence of antennæ. There are usually four pairs of legs, but in the pear-leaf blister-mite and its allies there are but two pairs. Besides the pear-leaf blister-mite, which is treated below, there are often found upon fruit trees in winter numbers of tiny, roundish, red eggs. These belong to a mite known as the clover mite (*Bryobia pratensis* Gar.). They rarely do damage to fruit trees in the East, but feed on clover and similar plants.

THE PEAR-LEAF BLISTER-MITE.

(*Eriophyes pyri* Scheut.)

This is a microscopic mite about one one-hundred and fiftieth of an inch long, with a slender body provided with two pairs of legs near the head end. Although each mite is so small as to do little damage of itself, it may become the parent of a vast assemblage capable of doing a great amount of injury. During the winter the mites remain hidden between the bud scales. Early in spring the mites move to the young unfolding leaves, eat through the under surface, and feed on the interior substance of the leaf. Here the mites increase a thousandfold. Some of these mites move out to form new galls, until a

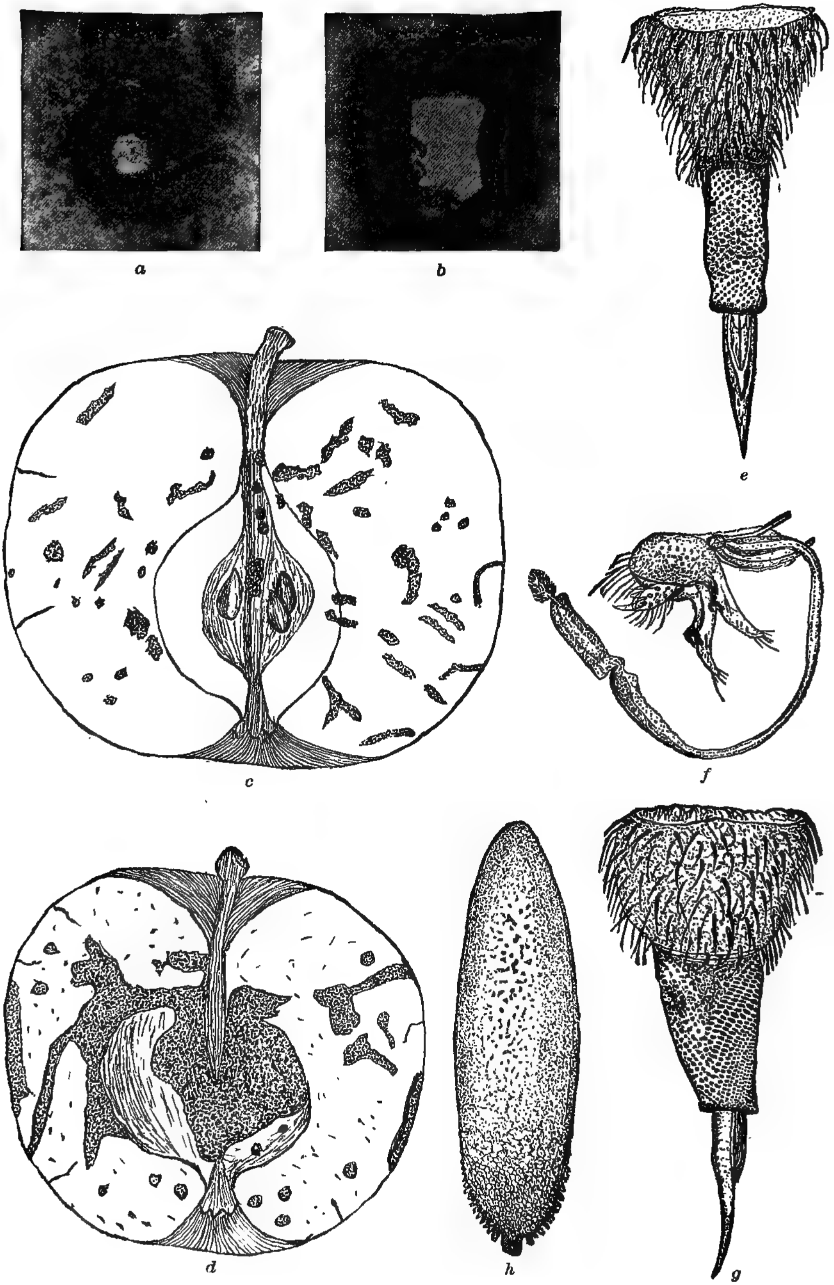

FIG. 42.—*Rhagoletis pomonella:* *a*, oviposition puncture in apple skin; *b*, exit hole of larva; *c*, *d*, work of larvæ in apple; *e*, *f*, *g*, details; *h*, egg. (Harvey.)

leaf becomes thickly spotted with them. Their feeding causes a thickening of the leaf at that spot, commonly called a blister or gall. This blister is at first of a reddish color, but it gradually turns brown, and finally black. In early fall, when the leaves ripen, the mites leave their galls and take refuge in the buds for the winter.

INSECTS INFESTING FRUITS.

Although few of the insects infesting fruit are liable to be transported upon nursery stock, several of them are such destructive pests as to merit the attention of all interested in horticulture.

* * * * * * *

The codling moth (*Carpocapsa pomonella* Linn.) passes the winter as a caterpillar in a cocoon in crevices or under loose pieces of the bark. However, they are not apt to occur on nursery trees. The cocoon is made of whitish silk and partially covered with bits of bark so that it is not easily seen. In early spring they pupate, and the moths issue to lay their eggs on young apples. The larva bores into the apple, usually from the blossom end, mines to the core, and then, when about full-fed, bores to the surface. It leaves the apple to pupate on the trunk or larger branches of the tree. Some issue in late June or July and again lay eggs on the apple, making a second brood. In the Northeastern States there is but one brood a year. The codling moth also attacks pears and quinces.

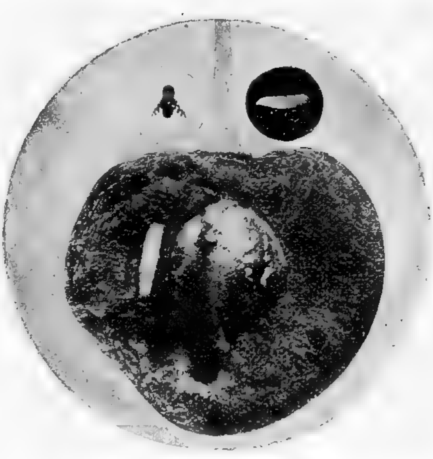

FIG. 43.—*Rhagoletis cingulata.* (Slingerland).

The apple maggot (*Rhagoletis pomonella* Walsh, fig. 42) is a two-winged fly that appears in June and lays its eggs just beneath the skin of apples. The white maggots, upon hatching, burrow throughout the apple in various directions. When full-fed the maggot drops to the ground, under which it pupates and emerges as a fly the next spring.

The cherry fruit-fly (*Rhagoletis cingulata* Loew, fig. 43) infests cherry in much the same manner as the apple maggot infests apples, and has a similar life history.

The plum curculio (*Conotrachelus nenuphar* Herbst.) is a small, grayish weevil that passes the winter under the bark of a tree or among rubbish. In spring it deposits eggs within the plum (peach or cherry) and then cuts a crescentic slit in the skin near by. The larva or grub soon hatches and feeds in the fruit, causing it to ripen prematurely and fall. The grub, when full-grown, passes into the ground and there pupates, the beetle issuing in the fall. The beetle has a peculiar habit of dropping from the tree when disturbed.

The quince curculio (*Conotrachelus cratægi* Walsh.) is a very similar insect to the plum curculio. It is the cause of knotty or wormy quinces. The weevil lays her eggs in little pits of the quince eaten by the parent for that purpose. The grubs feed in the quince till the early fall, when they leave it and burrow beneath the ground. Here they pass the winter, pupating in early spring.

The pear midge (*Diplosis pyrivora* Riley) is a tiny, two-winged fly much like the Hessian fly, that appears in the spring and lays its eggs in young pears. The larvæ feed near the core, causing the fruit to shrivel and drop. When full-fed they leave the fruit and pupate about an inch or so beneath the surface of the ground. The winter is passed in this condition, and the flies emerge the following spring.

O